Employment Impacts of Air-Pollution Controls at North Dakota Coal Plants

Prepared for

Sierra Club

by

Ian Goodman and Brigid Rowan

the goodman group, ltd.

www.thegoodman.com

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I. Summary

The purpose of this study is to estimate the employment impacts of pollution-control expenditures at the Milton R. Young and Leland Olds coal-fired plants in North Dakota.[1] The EPA's proposed requirement for the installation of Selective Catalytic Reduction (SCR)[2] for Olds Unit 2 and Young Units 1 and 2 will create **7,700 temporary jobs and 180 permanent new positions**. The 7,700 temporary jobs will include a wide range of jobs at the plants, at suppliers and throughout the US economy. **The bulk of the jobs will be in North Dakota where the SCR program will result in 5,100 temporary jobs and 130 permanent jobs**. Many of the remaining jobs will be filled by workers in Minnesota and other surrounding states. SCR Capital Costs for both plants total $513 million and Annual O&M Costs are $26 million. See Exhibit 1 below for a Summary of Temporary Employment Impacts of SCR Capital Costs. See Exhibit 2 for a Summary of Permanent Employment Impacts of SCR O&M (Operations and Maintenance) Costs.

Exhibit 1: Summary of Temporary Employment Impacts of SCR Capital Costs

	Young	Olds	Young + Olds
Capital Expenditures ($ million, 2012 $)	$358	$155	$513
North Dakota Temporary Employment Impacts			
Multiplier (Job-Years per $1 million, 2012 $)	10	10	10
Employment (Job-Years)	3,600	1,600	5,100
Total US Temporary Employment Impacts			
Multiplier (Job-Years per $1 million, 2012 $)	15	15	15
Employment (Job-Years)	5,400	2,300	7,700

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[1] An extensive description of the pollution-control retrofits is provided in Resource Insight, Inc.'s study by Paul Chernick, "The Cost of Clean Air" (2011). Details for the Young plant are on pp. 3-6, 11-12. Details for the Olds plant are on pp. 16-17, 21-22. See also FR (76 FR 58570-58648).

[2] See the Abbreviations and Acronyms section at the end of this study for a list of abbreviations and acronyms used in this work, in cited works, or in the field generally.

Exhibit 2: Summary of Permanent Employment Impacts of SCR O&M Costs

	Young	Olds	Young + Olds
Annual Expenditures ($ million, 2012 $)	$21.0	$5.0	$26.0
North Dakota Permanent Employment Impacts			
Multiplier (Job-Years per $1 million, 2012 $)	5	5	5
Annual Employment (Job-Years)	100	20	130
Total US Permanent Employment Impacts			
Multiplier (Job-Years per $1 million, 2012 $)	7	7	7
Annual Employment (Job-Years)	150	30	180

In addition to the EPA's proposed requirement for SCR, the North Dakota plants have already installed scrubbers (FGD) and other pollution-control measures required by North Dakota in its State Implementation Plan (SIP). The SIP expenditures translate to a significant employment impact in the US as a whole: 12,500 temporary jobs and 950 permanent ones. Again most of these jobs are in North Dakota with 8,400 temporary jobs and 680 permanent ones. SIP Capital Costs for both plants total $835 million and Annual O&M Costs are $68 million. See Exhibit 3, Summary of Employment Impacts of SIP & SCR Expenditures (Capital and O&M), below for a breakdown of the temporary and permanent jobs in North Dakota and the US as a whole for the SIP and SCR programs.

Finally, Exhibit 3 also demonstrates that together **the SIP and SCR programs** create impressive employment effects in the US. The two programs combined **deliver 20,200 temporary jobs and 1,130 permanent jobs to the US economy**. Most of these jobs are **in North Dakota** where the combined SIP and SCR measures will result in **13,500 temporary jobs and 810 permanent ones**. The combined SIP and SCR Capital Costs for both plants total over $1.3 billion and Annual O&M Costs are $94 million. These are sizable costs and have sizable job impacts. Moreover, given the current economic downturn and the potential for continued high unemployment rates over the next several years, these retrofits represent an excellent and very timely opportunity for North Dakota, neighboring states and the US.

Exhibit 3: Summary of Employment Impacts of SIP & SCR Expenditures (Capital and O&M)

	Young	Olds	Young + Olds
Capital Expenditures ($ million, 2012 $)			
State Implementation Plan (SIP)	$425	$410	$835
Total: SIP + SCR (Exhibit 1)	$783	$565	$1,348
North Dakota Temporary Employment Impacts			
Multiplier (Job-Years per $1 million, 2012 $)	10	10	10
Employment (Job-Years)			
State Implementation Plan (SIP)	4,300	4,100	8,400
Total: SIP + SCR (Exhibit 1)	7,900	5,700	13,500
Total US Temporary Employment Impacts			
Multiplier (Job-Years per $1 million, 2012 $)	15	15	15
State Implementation Plan (SIP)	6,400	6,200	12,500
Total: SIP + SCR (Exhibit 1)	11,800	8,500	20,200
Annual O&M Expenditures ($ million, 2012 $)			
State Implementation Plan (SIP)	$32.3	$35.8	$68.1
Total: SIP + SCR (Exhibit 2)	$53.3	$40.7	$94.0
North Dakota Permanent Employment Impacts			
Multiplier (Job-Years per $1 million, 2012 $)			
State Implementation Plan (SIP)	10	10	10
Total: SIP + SCR (Exhibit 2)	8	9	9
Annual Employment (Job-Years)			
State Implementation Plan (SIP)	320	360	680
Total: SIP + SCR (Exhibit 2)	420	380	810
Total US Permanent Employment Impacts			
Multiplier (Job-Years per $1 million, 2012 $)			
State Implementation Plan (SIP)	14	14	14
Total: SIP + SCR (Exhibit 1)	11	13	12
Annual Employment (Job-Years)			
State Implementation Plan (SIP)	450	500	950
Total: SIP + SCR (Exhibit 2)	600	530	1,130

So in addition to the reduction of harmful pollutants, as well as health and visibility benefits, pollution-control measures undertaken in the SIP program and proposed in the SCR program deliver important economic development benefits. The Goodman Group, Ltd. (TGG) derived the employment impacts discussed here using an Input-Output analysis, which considers a wide range of job effects, both on-site at the North Dakota plants and throughout the US economy. This study explains the derivation of the employment impact estimates and provides more detailed results in Section IV.

II. Selection of Model

A comprehensive analysis of the employment impacts of the pollution controls must consider the full range of expenditures and the full range of job effects associated with these expenditures. As noted above, these retrofits entail over $1.3 billion in capital costs, as well as sizable operating costs.

To estimate the employment impacts for the pollution controls, TGG has reviewed a number of employment analyses and selected an Input-Output (I-O) model as the most appropriate method. Input-Output models, such as IMPLAN[3], the standard macroeconomic Input-Output model in the US, are used “used by hundreds of government agencies, colleges and universities, non-profit organizations, corporations, and business development and community planning organizations”[4], including TGG. North Dakota’s Lignite Energy Council also commissions annual employment impact studies, based on Input-Output analysis.[5] Input-Output models generate regional economic impact estimates by

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[3] IMPLAN is a macroeconomic Input-Output model that was developed at the US Forest Service and the University of Minnesota and is now maintained by the Minnesota IMPLAN Group. IMPLAN was created because there were no methods for translating national economic statistics from the U.S. government into functional data for regional economies to use. Therefore a system was required to model regional economic impacts quickly and efficiently. Using classic Input-Output analysis in combination with regional-specific Social Accounting Matrices and Multiplier Models, IMPLAN provides a simple yet robust set of tools to efficiently and accurately model regional economic impacts. This model very concretely and specifically traces the economic interaction for expenditures in 440 separate industries, which reflect the US economy. IMPLAN incorporates a multiplier for each of the 440 industries represented in the model. There is an IMPLAN model for the US as a whole and an IMPLAN model for each individual state.

[4] Citation from IMPLAN’s website: <http://implan.com/V4/index.php?option=com_content&view=section&layout=blog&id=33&Itemid=2 >. This link also provides a description of the IMPLAN system. For a partial list of IMPLAN’s many clients, who use its Input-Output model, see < http://implan.com/V4/index.php?option=com_content&view=article&id=64&Itemid=25 >.

[5] The Lignite Energy Council is a trade association representing North Dakota’s four lignite mines, along with the lignite-based power plants (including Milton R. Young and Leland Olds), the Dakota Gasification Company and more than 300 companies that supply goods and services to the lignite industry. Annual economic studies of the lignite industry have been produced by the

first tracing the industries involved in a study region throughout successive rounds of supply linkages. At each step, they trace the portion of the inputs required from each industry which are supplied locally (within the regional economy being modeled).

Input-Output analyses consider a wide range of job impacts and include the following categories of effects:

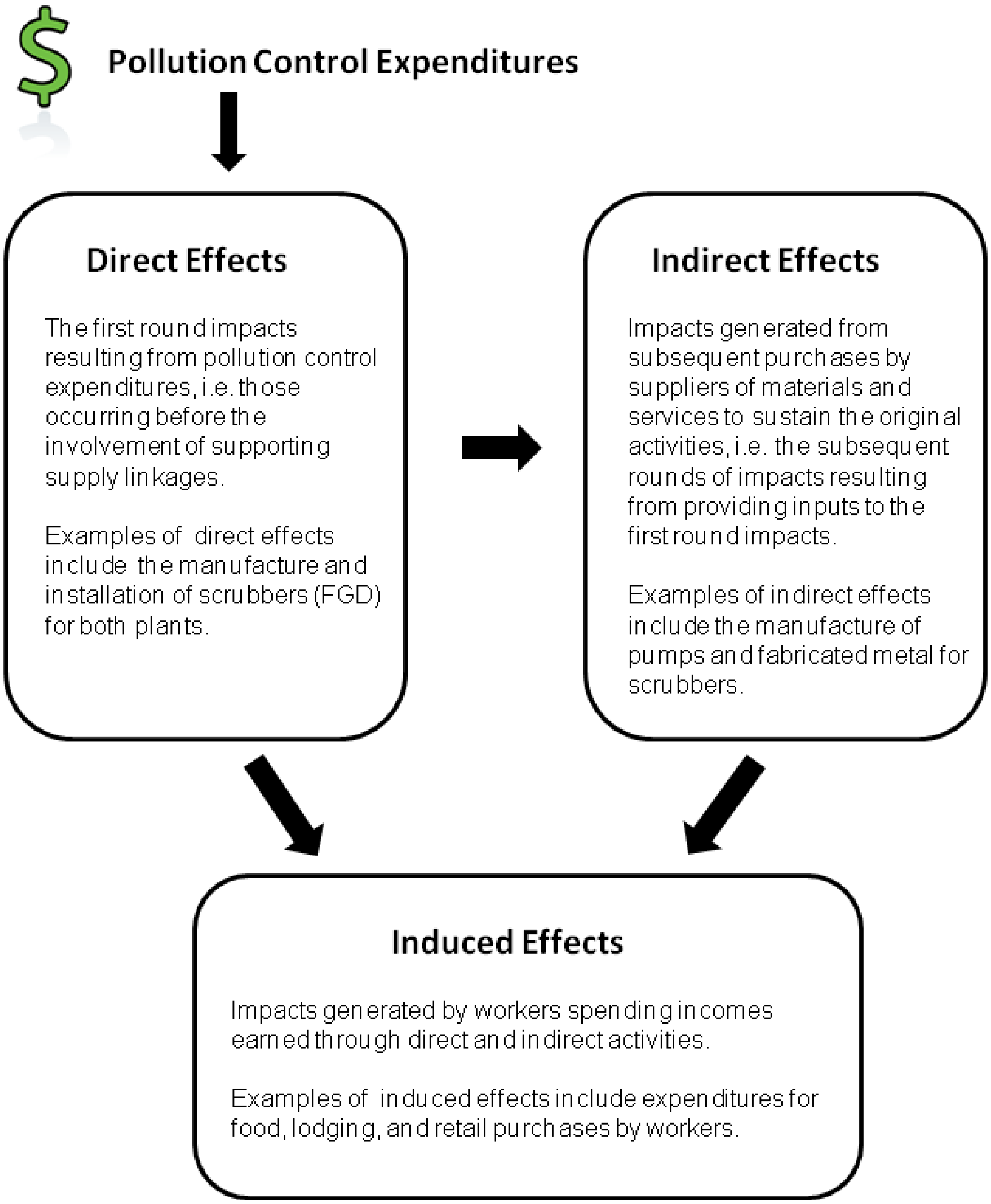
> *Direct Effects* — first round impacts of a set of expenditures, i.e. those occurring before the involvement of supporting supply linkages;
>
> *Indirect Effects* — impacts generated through subsequent purchases by suppliers of materials and services to sustain the original activities;
>
> *Induced Effects* — impacts generated by workers spending incomes earned through direct and indirect employment activities;
>
> *Total Effects* — the sum of the direct, indirect, and induced effects.

Pollution-control expenditures have direct, indirect, and induced effects. Respending (i.e., the change in economic activity as consumers change their spending for other goods and services) has induced effects, and may also have direct and indirect effects. Exhibit 4 below illustrates the economic supply linkages associated with these categories of effects, using the installation and manufacture of scrubbers (FGD)[6] as examples.

North Dakota State University (NDSU) Department of Agribusiness and Applied Economics since 1982. Lignite Energy Council (2011); Coon and Leistritz (2006, 2007, 2008, 2009b, 2010a, 2011).

[6] Flue-gas desulfurization.

Exhibit 4: Economic Supply Linkages Associated with Categories of Employment Effects



Pollution Control Expenditures

Direct Effects

The first round impacts resulting from pollution control expenditures, i.e. those occurring before the involvement of supporting supply linkages.

Examples of direct effects include the manufacture and installation of scrubbers (FGD) for both plants.

Indirect Effects

Impacts generated from subsequent purchases by suppliers of materials and services to sustain the original activities, i.e. the subsequent rounds of impacts resulting from providing inputs to the first round impacts.

Examples of indirect effects include the manufacture of pumps and fabricated metal for scrubbers.

Induced Effects

Impacts generated by workers spending incomes earned through direct and indirect activities.

Examples of induced effects include expenditures for food, lodging, and retail purchases by workers.

Total Effects = Direct + Indirect + Induced Effects

In order to use the Input-Output model to value the economic development impacts for pollution controls, various specific input data are required. The two key inputs for this model are cost expenditures associated with the projects, as well as job multipliers. In analyses of employment impacts, it is standard practice to provide results in terms of multipliers. In particular, a useful summary metric is jobs per dollar (typically expressed as person-years of employment per $1 million of project-related spending). Multipliers facilitate comparison of results within and across studies. With results expressed in terms of multipliers, projects (and other activities) with differing levels of spending can be compared to determine relative intensity of impacts. Projects with higher jobs per dollar are more labor-intensive.

Our economic development research is supported by an extensive database containing IMPLAN-derived multipliers and other specific information on a wide range of energy supply options and efficiency measures. This database has been compiled from utility data, detailed engineering studies, and contractor records from across North America.

In conjunction with TGG's extensive database, we developed E^3AS (Energy, Economic, and Environmental Analysis System) software on behalf of the US EPA (Office of Air and Radiation) in 1996 as a tool to conduct high-quality Input-Output-based analyses on various energy supply options.[7] The multipliers in TGG's database, used in this study's Input-Output analysis, are derived from IMPLAN.

TGG has concluded from its extensive review of numerous groups of analyses that the Input-Output model, done well and carefully, is best-suited to estimate the employment impacts in this study for two main reasons. One, the model

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[7] TGG has made E^3AS available to assist government agencies in evaluating the economic and environmental impacts of energy supply and efficiency programs, and in considering both the benefits and costs of energy alternatives. The E^3AS software uses our extensive database for its Input-Output-based economic analyses, which have been incorporated into all TGG studies of economic and environmental impacts, including the current study, since 1996. E^3AS model analysis offers a high level of regional specificity (and hence more precise results in evaluating regional economic impacts) because it has been developed using state-specific data and leveraging TGG's extensive expertise in energy efficiency, regional economics and utility operations. See specific references to TGG's website in Footnote 11 for further information.

takes into account a wide range of effects in the estimation of the employment impacts for the North Dakota pollution controls – and thus provides the most realistic overall results.[8] Two, Input-Output is a very strong tool that models regional employment impacts and provides high-quality multipliers that are well-tailored to specific expenditures. However, care must be taken in applying the model and additional effort must go into the customization of this model for the pollution-controls in this study.

The pollution retrofits in this study present two important challenges in the judicious application of an Input-Output model: (i) the highly complex and heterogeneous nature of these retrofits; (ii) the availability of detailed expense breakdowns from the utilities. How these challenges were met in our derivation of inputs for the pollution-control expenditures is discussed in Section III.B below.

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[8] In the context of full employment, the Input-Output model is not as directly representative of the real world because the model assumes no constraints on supply of inputs, such as labor. However, given the current economic downturn, characterized by substantial slack labor and other productive capacity, Input-Output analysis more closely models the situation in the real world. Appendix A cites Schmalensee and Stavins (2011), who provide further support as to why a time of high unemployment and sluggish economic recovery is favorable for using slack labor capacity to meet environmental regulatory requirements. Conversely the Appendix also discusses why using labor to meet regulatory requirements during a time of full employment may impose opportunity costs on society and thus provide less net economic benefit.

III. Study Approach – Input-Output Model

A. Analytical Framework

This analysis calculates the employment impact for pollution controls at the plants in North Dakota in terms of one macroeconomic indicator, i.e., Employment, expressed in job-years. One job-year is equivalent to one full-time job for one person for one year. This Employment macroeconomic indicator measures the change in employment from pollution-control expenditures. Changes in Employment are determined by taking the sum of the following two components:

[1] the <u>increase</u> in economic activity as a result of expenditures on pollution controls; and

[2] "<u>respending</u>," the <u>change</u> in economic activity as consumers <u>change</u> their spending for other goods and services; to the extent pollution controls affect consumers' overall costs,[9] these changes will affect other spending.

For each of these components, the related Employment indicator is calculated as the product of expenditures and the multiplier. So the Employment indicator specific to pollution-control expenditures (component [1]) is calculated as follows:

Pollution-control expenditures ($ million) <u>multiplied by</u>

Employment multiplier for pollution-control expenditures (job-years per $ 1 million of expenditures).

Likewise, the Employment indicator specific to respending (component [2]) is calculated as follows:

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[9] Implementation of pollution controls can result in higher electricity costs paid by consumers and thus reduce spending for other goods and services. Pollution controls can also result in offsetting cost savings (e.g., by reducing disease, property damage, and costs to implement alternative pollution controls); these cost savings will thus increase spending for other goods and services. Respending is thus the overall change in consumer spending, reflecting both cost increases and savings.

Changes in consumer spending ($ million) multiplied by

Employment multiplier for consumer spending (job-years per $ 1 million of expenditures).

The multipliers for each component (pollution-control expenditures and respending) are estimated using an Input-Output model of the North Dakota economy. The derivation of these multipliers will be further discussed below.

The calculations presented above are the framework for this economic development impact analysis. As indicated above, in order to use an Input-Output model to value the employment impacts (i.e. the sum of the direct, indirect, and induced effects) for the pollution-control equipment, various specific input data are required. The two key inputs in an Input-Output analysis are cost expenditures associated with the projects, as well as job multipliers. These key inputs are discussed in the following two sections, III.B and III.C, which describe the respective input assumptions for pollution-control expenditures and respending.

B. Input Assumptions – Pollution-Control Expenditures

1. Estimating Pollution-Control Expenditure Breakdown

As emphasized throughout this study, a comprehensive employment impact analysis must consider the full range of expenditures and the full range of job impacts associated with these expenditures. Typically, cost data are front and center in an employment impact study. Job impacts for a project can only be meaningfully considered in the context of project-related expenditures. In other words, to estimate jobs, we need to know what the money is being spent on.

Cichanowicz (2010), pp. 4-1 – 4-2 provides a good review of factors affecting capital costs:

CAPITAL COST ESTIMATING METHODOLOGY

Evaluating the capital cost of environmental controls requires a consistent accounting of costs. Both the costs directly incurred due to process equipment, and indirect costs imposed on plant and operations, must be accounted for. EPRI's Technical Assessment Guide (EPRI, 1993) provides a consistent methodology, and has served as a model by which DOE, EPA, and other organizations assess costs.

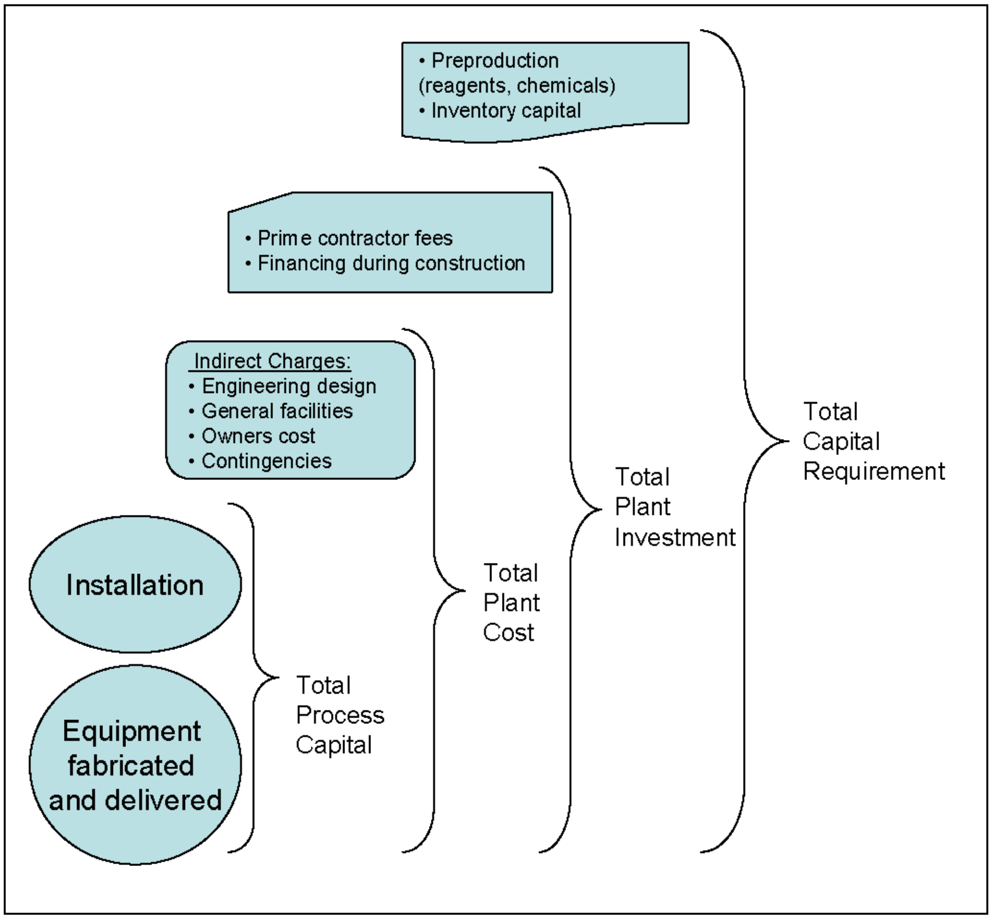
Figure 4-1 [Exhibit 5] schematically depicts the key components of a capital cost estimate. The capital equipment directly purchased from the supplier, and installed by a construction contractor comprises the Total Process Capital. Several indirect charges consequential to these direct charges are incurred: (a) engineering design, (b) general facilities, (c) owners' costs, and (d) contingencies (usually both a process and a project). Contingencies are key planning cost elements that are usually absorbed as a project evolves. Indirect fees should be consistent when comparing costs from various suppliers. Table 4-1 [Exhibit 5] presents typical ranges of values historically used by EPRI, DOE, and EPA. Together with the Total Process Capital, these indirect charges comprise the Total Plant Cost.

A second series of indirect charges is incurred based on project execution: fees for the prime contractor, and financing for the construction period. Adding these costs to the Total Plant Cost determines the Total Plant Investment.

Finally, the equipment and site must be equipped with spare parts, and a supply of reagents, chemicals, or fuels, prior to operation. These pre-production charges and inventory capital complete the Total Capital Requirement.

Ideally, evaluating capital costs would utilize similar charges as defined in Figure 4-1 and Table 4-1 [Exhibit 5].

Exhibit 5: Depiction of Project Capital Cost Elements
[Figure 4-1 and Table 4-1 in original Cichanowicz (2010)]



Examples of Indirect Charges, Assumptions

Cost Element	Purpose	Range, % of Project Cost
Engineering	Establish design	7-15
General Facilities	Roads, buildings, shops, laboratories	2-5, based on process capital
Owner's Cost	Staff, management	5-10
Process Contingency	Uncertainty in process operation	5-10, for a mature process
Project Contingency	Uncertainty in site installation	5-10, if detailed engineering initially completed
Prime Contractor Fees	Business cost	2-8
AFDC	Financing during construction	5-10
Preproduction	Supply of parts, consumables	2, based on total process investment, plus 30 days fixed, variable O&M
Inventory Capital	Supply of consumables	Based on 30 day reagent, chemicals storage

As stated above, a comprehensive employment impact analysis must consider the full range of expenditures and the full range of job impacts associated with these expenditures. Because every pollution retrofit is somewhat unique, multipliers must be developed to correspond to the various pollution-control measures in the retrofit. Thus a detailed and comprehensive breakdown of the pollution-control expenditures is needed to meaningfully consider the full range of expenditures and then derive the multipliers necessary to calculate the associated job impacts.

In the case of a coal-plant retrofit, estimating pollution-control expenditures is a complicated issue. In the case of the Olds and Young plants, the pollution controls at each plant are broadly similar and involve a similar group of technologies. However despite these similarities, the detailed expenditure mix at each plant may be substantially different with respect to various inputs. For example, the capital costs for Young SIP retrofits (totaling $425 million) include $130 million in electrical improvements (about 30% of the total).[10] These differences in expenditure mix can result in different employment impacts.

Exhibit 5 depicts cost elements associated with a large capital project, such as a retrofit. This exhibit serves as a guide in developing a detailed and comprehensive expenditure breakdown to meaningfully consider the full range of expenditures. As discussed in more detail in Appendix A, TGG has conducted an extensive literature review of various analyses of employment impacts of pollution-control expenditures. This review of other analyses (i.e. utility estimates, estimates of jobs based on expenditure mix and labor requirements and the results of other Input-Output studies) has also been very useful as a guide in creating a detailed expenditure breakdown specific to pollution-control retrofits.

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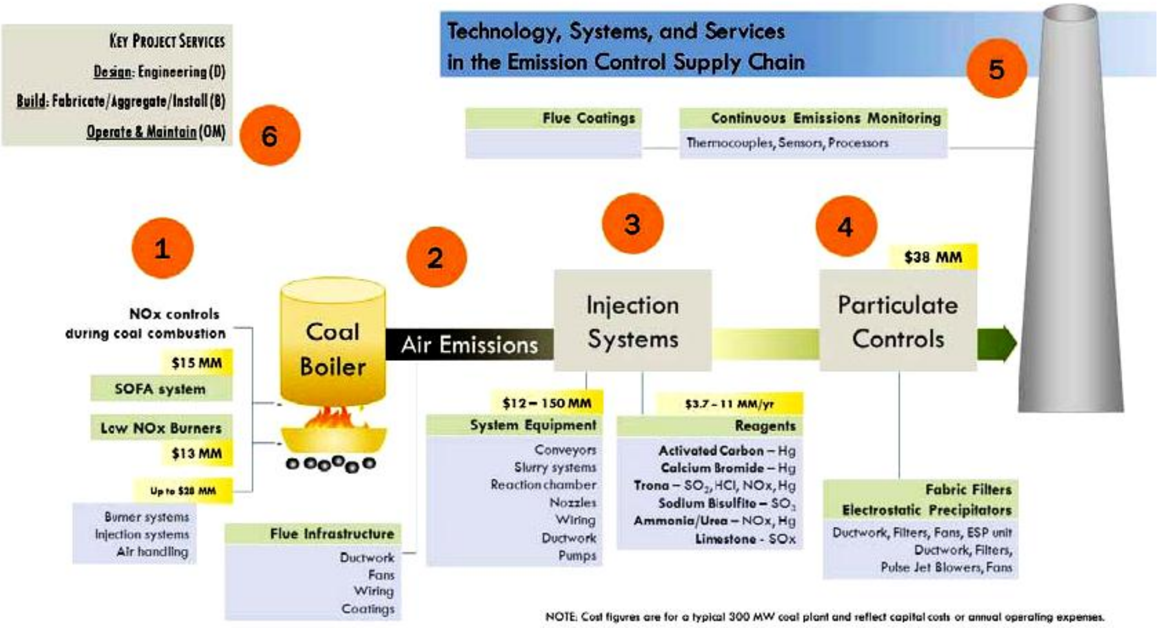
[10] By definition, the total of all expenditure shares sum to 100%. So if a retrofit has a higher proportion for one type of spending (e.g., electrical costs at Young), it will have a correspondingly lower proportion for other types of spending (e.g., non-electrical costs at Young). As reported in Cichanowicz (2010), p. 4-3, electrical infrastructure is typically 5-6% of an FGD budget, escalating to more than 10% during periods of peak copper pricing. So the expenditure mix at Young is characterized by an unusually high proportion of electrical costs.

Ceres (2011), pp. 3-4 provides a very useful description of the supply chain for coal plant pollution controls and how it is distributed geographically:

> ### What is the Supply Chain?
>
> The supply chain for air pollution control comprises the companies that design, build, and maintain the pre- and post-combustion equipment and systems that reduce harmful emissions from power plants. Figure 1 [Exhibit 6] shows where the equipment would be found. For control of nitrogen oxides, separated over-fire air (SOFA) systems and low NOx burners may be used during coal combustion (1). Following combustion, the resulting emissions need to be conveyed through ductwork; fans, wiring, ducts, and duct coatings play an important role here (2).
>
> Further removal of sulfur dioxide, nitrogen oxides, and toxic pollutants is taken care of by an injection system (3) that is designed to apply a reagent to the flue gas. Common types of injection systems include: selective catalytic reduction (SCR), flue gas desulfurization (FGD), activated carbon injection (ACI), and dry sorbent injection (DSI). This is a technology- and equipment-intensive process, requiring mixers, conveyors, storage tanks, and spray nozzles. Whenever the injection system is operating, reagents such as trona and ammonia need to be present. The chemical reactions that take place lead to the formation of solid particles. Some of these can be removed by gravity, while others need to be filtered out of the flue gas using particulate controls (4), often consisting of fabric filters and fans. Finally, the cleaned flue gas is monitored (5) and vented to the atmosphere.
>
> Most companies in the supply chain perform multiple services (6), from designing and drawing up engineering plans, to fabrication, installation, operation, and maintenance of components and systems. Numerous local companies often perform demolition and site work and facilitate the integration systems into an existing plant.

Exhibit 6: Segments of the Supply Chain

[Figure 1 in original Ceres (2011)]



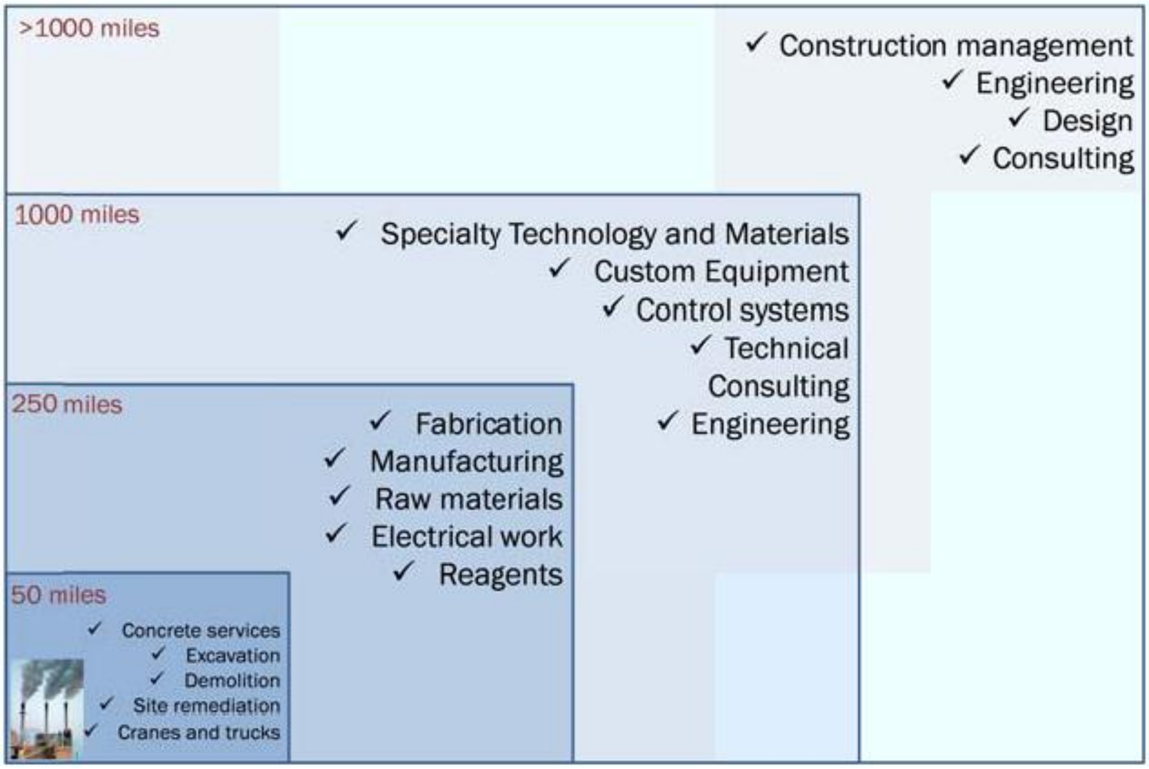
NOTE: Cost figures are for a typical 300 MW coal plant and reflect capital costs or annual operating expenses.

Mapping the Impact-Measuring the Potential

Constructing power plants and APC systems takes resources, equipment, and expertise from around the country. From demolition to re-commissioning, a single construction project could involve companies from a neighboring town working alongside teams from across the country. Each project is unique, but plant owners tend to source parts, equipment, and materials from nearby locations to minimize the costs of shipping heavy cargo. Services, meanwhile, may come from farther afield, especially if a project requires specialized skills or knowledge. Figure 2 [Exhibit 7] shows how supply chain firms are often located in relation to a given project.

Exhibit 7: Regions of Impact for a Typical Power Plant Construction Project

[Figure 2 in original Ceres (2011)]



The presence of firms in the supply chain maps to the location of their customers as well as the availability of key inputs of natural resources and skilled workers. But one thing is clear: American businesses across the country provide the products, expertise, and services necessary to update our fleet off older coal-fired power plants. These businesses provide engineering, design, construction, and maintenance services, and manufacture the many different types of equipment needed in APC systems. Figure 3 [Exhibit 8] shows the locations of major operations for 175 supply chain companies that were identified for this report.

Exhibit 8: U.S. Locations of Key Supply Chain Companies [Figure 3 in original Ceres (2011)]

As this supply chain discussion illustrates, coal-plant pollution retrofits in North Dakota will generate sizable in-state economic activity. As shown in Exhibit 7, much of the supply chain will be located near the retrofits. As shown in Exhibit 9, retrofits in North Dakota will also generate sizable economic activity in Minnesota, other neighboring states and throughout the US.

2. Deriving Pollution-Control Expenditure Multipliers

Commercially available Input-Output models do not provide specific multipliers for supply options (including pollution control), nor for energy efficiency options. To develop these specific Input-Output multipliers, the total expenditures for each type of supply and energy efficiency activity must be disaggregated into expenditures for each of the specific industries represented in the Input-Output model. The data used to perform this translation for each activity is called a bill of goods (BOG), i.e., the allocation of expenditures for each type of supply and energy efficiency technology. The BOG data that are utilized in this study were developed by TGG in an extensive research effort ongoing since 1992.[11]

TGG's BOG data provide a high level of expenditure detail for a comprehensive set of electric and gas supply and energy efficiency options. For electricity supply technologies, BOG data were largely based on (i) engineering studies performed by Oak Ridge National Laboratories for inclusion in the U.S. Department of Energy (DOE) Energy Economic Database; (ii) utility accounting records; and (iii) Electric Power Research Institute (EPRI) Technology Assessment Guide (TAG) data. For efficiency technologies, BOG data were principally derived from Massachusetts Electric accounting records, which incorporated all aspects of costs (program administration, overhead, labor, and consulting services, as well as materials and equipment).

As discussed in Section II, these retrofits present two important challenges in the judicious application of an Input-Output model in this study: (i) the highly complex and heterogeneous nature of these pollution controls; (ii) the availability of detailed expense breakdowns from the utilities. In particular, these two challenges affect the derivation of multipliers for the pollution-control expenditures.

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[11] See TGG's website for further explanation of how our extensive database of information on supply options and energy efficiency measures was developed and is used in Input-Output-based economic development studies. < http://www.thegoodman.com/economic-development >. For further information on our economic development studies conducted using this database, see < http://www.thegoodman.com/economic-development-projects >.

Pollution-control retrofits (such as those in the SIP and SCR) are complex and heterogeneous.[12] Each retrofit needs to be tailored for a specific power plant, including the mix of pollution-control equipment and the work to integrate that equipment in the specific plant. Moreover, there are a number of different types of coal plants. Emissions from each plant vary as a function of the type of coal and the boiler used. Site configuration and conditions (i.e., how the plant is laid out and how controls can be implemented feasibly within space available) also vary. The retrofits at the North Dakota plants are even more tailored because they reflect the special characteristics of North Dakota-lignite coal plants. Moreover, within each program (i.e., State Implementation Plan and proposed EPA), there is a mix of control technologies.

The second major challenge in this study was that unlike the studies that TGG has conducted on behalf of utilities, detailed expenditure breakdown from the North Dakota utilities is not readily available.

To overcome the challenges of heterogeneity and lack of detailed expenditure breakdown, TGG used three interrelated and mutually reinforcing approaches to derive the multipliers for pollution-control expenditures:

1. We examined the available information about the retrofits at the Young and Olds plants. Sources include documentation from the utilities and the EPA, as well as Resource Insight, Inc.'s study, "The Cost of Clean Air", Chernick (2011).
2. We conducted an extensive review of numerous studies examining the employment impacts of pollution-control expenditures. These studies provided relevant information regarding pollution-control retrofits and the related expenditure breakdown.

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[12] The key site and design factors that affect capital costs of pollution control retrofits are described in Cichanowicz (2010), pp. 4-3 – 4-4. The specific factors identified are Fuel Composition, Site Congestion and Retrofit Difficulty, Existing Site Auxiliary and Support Facilities, Flue Gas Draft System Upgrades, Waste Water Treatment Requirements, Stack Rebuild or Replacement, Equipment Sparing and Redundancy Philosophy, Materials of Construction, and Capital versus Operating Cost. Of these factors, site complexity is specified as perhaps the most important.

3. Finally, we analyzed TGG's BOG data, including the underlying details and the specific multipliers associated with various technologies, to find BOGs that were as close as possible to the expenditure mix for the pollution-control retrofits. Because of the high level of heterogeneity associated with the pollution controls at the North Dakota plants, there was no single BOG that was directly applicable from the TGG database. Fortunately, the TGG database does contain one BOG ("FGD system retrofit at existing pulverized coal unit") that is a highly representative of a significant portion of the retrofits at the Young and Olds plants. In addition to the FGD BOG, we selected a number of BOGs with similar components to the retrofits and identified patterns across these data.[13] We applied our expert judgment to these selected representative TGG BOGs to derive a reasonable range of multipliers corresponding to the various pollution-control measures in this study. Data from strategies 1. and 2. (described above) were used as inputs for the expenditure mix for each retrofit, and also as checks of reasonableness for the range of multipliers derived from the TGG BOG data.

C. Input Assumptions – Respending

As explained above, respending is the change in economic activity as consumers change their spending for other goods and services. To the extent pollution controls affect consumers' overall costs, these changes will affect other spending. Respending is thus a rather broad concept; complexity arises both in terms of estimating overall cost changes, and in estimating employment multipliers for any cost changes.

For the purposes of this study, respending, with respect to overall cost changes, is assumed to be zero. Put another way, any consumer cost increases (notably

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[13] Representative BOGs in the TGG database include: several types of new power plant and other utility construction (i.e., new facilities such as a new pulverized coal unit with FGD and substation to supply power to pollution control systems); and O&M (i.e., consumables for pollution control equipment, and repair/replacement/minor upgrading).

due to electricity rate and bill increases) are assumed to be offset by other savings. The pollution controls are thus assumed to be cost-effective, in that the benefits (cost savings) are at least as large as the costs.

Studies have consistently demonstrated that EPA Air Quality Regulations produce benefits far in excess of costs.

According to “A Guide to Economic and Policy Analysis of EPA’s Transport Rule” by Schmalensee and Stavins (2011):

> Because SO_2 and NO_X are “precursors” to ozone (i.e., smog) and $PM_{2.5}$,[14] reductions in upwind SO_2 and NO_X emissions can help reduce ambient ozone and $PM_{2.5}$ concentrations in downwind regions.[15] [p. 4][16]
>
> […]
>
> Existing EPA regulations to limit emissions of SO_2, NO_X and other criteria pollutants have created significant benefits in terms of health improvements, aesthetic amenities, recreational benefits, and ecosystem enhancements. OMB estimates that EPA air rules in place as of 2010 account for $93 billion to $629 billion (2009$)[17] in annual benefits, reflecting the vast majority (94 to 97 percent) of the benefits from all EPA regulations and a large share (60 to 84 percent) of the benefits from all

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[14] [Footnote 4 in original] Through chemical reactions in the atmosphere, both SO_2 and NO_X emissions can lead to atmospheric ozone and fine particulates, both of which have adverse health consequences. ($PM_{2.5}$ refers to fine particulates smaller than 2.5 micrometers which can be inhaled deeply causing serious respiratory problems.) Ozone, commonly known as smog, is formed in the atmosphere when hydrocarbon vapors react with nitrogen oxides in the presence of sunlight. Both SO_2 and NO_X can be transformed through atmospheric chemical reactions into small particulates.

[15] [Footnote 5 in original] The Transport Rule would limit annual SO_2 and NO_X emissions in 28 states, and seasonal NO_X emissions in 26 states.

[16] The health dangers and toxic effects of fine particulates are well-documented. According to Chernick (2011), p. 4:

> Once out of the power-plant smokestack, both sulfur dioxide and nitrogen oxides condense into fine particles that penetrate deep into the lungs, cause respiratory diseases, aggravate cardiovascular disease, and form visible haze. When they wash out of the air, these pollutants form acids—sulfuric, nitric, and nitrous—that damage property and acidify lakes, rivers, streams, and soils. In addition, oxides of nitrogen react with other atmospheric pollutants to form smog and ground-level ozone, which have multiple effects on health and visibility.

[17] [Footnote 19 in original] Throughout the paper, values from other studies are converted into 2009 dollar values using the GDP price deflator. Bureau of Economic Analysis, “Price Indexes for Gross Domestic Product,” 2010.

> federal regulation.[18] Most of these air quality benefits are attributable to rules that target reductions in $PM_{2.5}$ pre-cursor emissions of SO_2 and NO_X. EPA estimates even larger annual benefits – $1.3 trillion annually in 2010 – from the CAA than those estimated by OMB.[19]
>
> The electric power sector currently accounts for roughly 75 percent of national SO_2 emissions and 20 percent of national NO_X emissions.[20] Further reductions in SO_2 and NO_X power plant emissions can potentially yield a wide variety of benefits, including reduced mortality, reduced incidence of respiratory and heart disease, improved visibility, enhanced agricultural and forestry yields, greater environmental amenities, and improved ecosystem services.[21] Moreover, these benefits come in many forms, including improved well-being, reduced health-care expenditures, and improved work-productivity from reduced sick days. The magnitude of these health benefits will depend upon the size and location of emission reductions, the resulting improvements in air quality, and the valuation of health benefits that arise from these air quality improvements. [pp. 7-8]

As emphasized by Schmalensee and Stavins (2011), p. 7, most of the air quality benefits listed above “are attributable to rules that target the reduction of $PM_{2.5}$ pre-cursor emissions SO_2 and NO_x.” And the pollution retrofits in North Dakota, including proposed SCR requirement, specifically target these reductions.

In light of these very large benefits, the assumption of zero respending in the case of these pollution-control retrofits is in fact conservative.

The Clean Air Task Force (CATF) has commissioned comprehensive studies of health impacts caused by fine particle air pollution from the nation’s roughly 500 coal-fired power plants. CATF’s studies issued in 2000, 2004, and 2010 were performed by Abt Associates and incorporated the latest scientific findings

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[18] [Footnote 20 in original] These aggregate figures generally reflect benefits as estimated by EPA. OMB, Office of Information and Regulatory Affairs. “2010 Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities.” 2010, pp. 10-14.

[19] [Footnote 21 in original] This estimate includes reductions from CAIR and the Clean Air Mercury Rule, which has since been vacated. “The Benefits and Costs of the Clean Air Act from 1990 to 2020,” Office or Air and Radiation, March 2011.

[20] [Footnote 22 in original] EPA, Nitrogen Oxide and Sulfur Dioxide Emissions by Sector, 2005.

[21] [Footnote 23 in original] For example, reductions in nitrogen and acid deposition may improve agricultural and forestry yields.

concerning the link between air pollution and public health, as well as up-to-date emissions information.[22] Each study found that emissions from the U.S. power sector cause tens of thousands of premature deaths each year and hundreds of thousands of heart attacks, asthma attacks, emergency room visits, hospital admissions, and lost workdays.

As reported in CATF (2010), p.4 (emphasis added):

> although coal plant emissions of key particle-forming pollutants like sulfur dioxide (SO_2) and nitrogen oxides (NO_x) have declined significantly over the last several years, existing plants remain among the top contributors to fine particle pollution in the United States. As a result, their emissions continue to take a significant toll on the health and longevity of millions of Americans.
>
> Specifically, **Abt Associate's analysis finds that fine particle pollution from existing coal plants is expected to cause nearly 13,200 deaths in 2010.** Additional impacts include an estimated 9,700 hospitalizations and more than 20,000 heart attacks per year. **The total monetized value of these adverse health impacts adds up to more than $100 billion per year.** This burden is not distributed evenly across the population. Adverse impacts are especially severe for the elderly, children, and those with respiratory disease. In addition, the poor, minority groups, and people who live in areas downwind of multiple power plants are likely to be disproportionately exposed to the health risks and costs of fine particle pollution.
>
> These figures take into account emissions reductions from regulatory changes […]
>
> Comparing estimated health impacts from the 2004 analysis and this updated assessment serves to underscore the direct link

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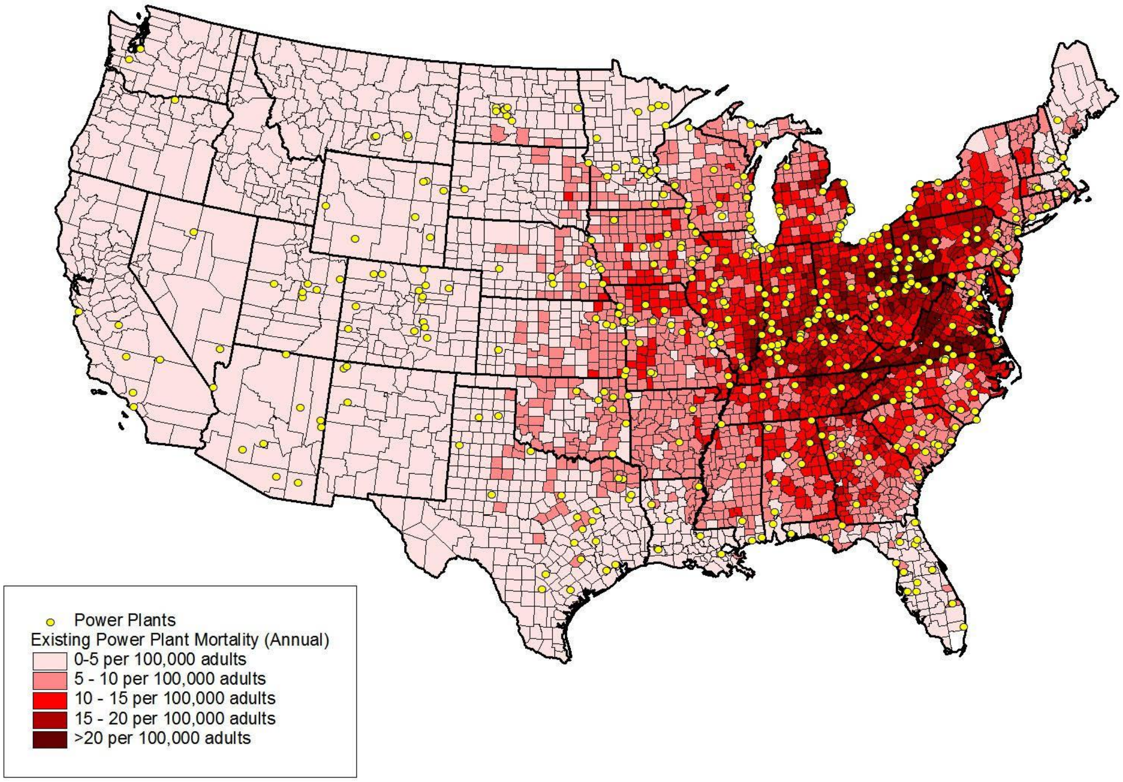
[22] CATF (2010).

> between reduced power plant emissions and substantial public health benefits. For example, Abt Associates' estimate of 13,200 deaths from fine particle pollution in 2010 compares to an estimate of nearly 24,000 deaths per year from existing plants in the 2004 study. Similar public health gains are evident in the estimated incidence of other adverse impacts including hospital admissions (9,700 in 2010 compared to 21,850 in 2004) and heart attacks (20,400 in 2010 compared to 38,200 in 2004).

Exhibit 9 shows how these health risks and costs are distributed geographically. Clearly those areas with the highest concentration of coal plants (indicated by yellow circles on the map) and downwind of those concentrations bear a disproportionate share of the aggregate burden of adverse impacts.

Exhibit 9: Mortality Rates from Small Particulates from Coal-fired Power Facilities



Source: Clean Air Task Force (2010). Analysis by Abt Associates.

North Dakota’s cluster of lignite plants (including Milton R. Young and Leland Olds) is apparent on the map in Exhibit 9 as the group of yellow circles in the west-central area of the state. Compared with areas of the US to the east and south, there are very few coal plants located to the west (upwind) of North Dakota. As a result, mortality rates in North Dakota are not as high as in the areas to the east and south that are downwind of multiple coal plants. But, as noted in CATF (2010), p. 8:

> Adverse effects, including excess mortality, occur even at low ambient concentrations of fine particles—suggesting there is no “safe” threshold for this type of pollution.

As shown in Exhibit 10, emissions from the Milton R. Young and Leland Olds plants have very substantial adverse health impacts, valued at approximately $500 million annually.

Exhibit 10: Adverse Health Impacts from Air Emisisons: Milton R. Young and Leland Olds Plants

	Incidents (Annual)	Valuation ($000)
Milton R. Young Plant		
Deaths	37	$272,927
Heart Attacks	58	$6,282
Asthma Attacks	633	$33
Hospital Admissions	27	$633
Chronic Bronchitis	23	$10,251
Asthma ER Visits	38	$14
Total	816	$290,140
Leland Olds Plant		
Deaths	26	$189,046
Heart Attacks	40	$4,355
Asthma Attacks	438	$23
Hospital Admissions	19	$439
Chronic Bronchitis	16	$7,104
Asthma ER Visits	26	$10
Total	565	$200,975
Total: Young + Olds		
Deaths	63	$461,972
Heart Attacks	97	$10,637
Asthma Attacks	1071	$56
Hospital Admissions	46	$1,072
Chronic Bronchitis	39	$17,355
Asthma ER Visits	65	$24
Total	1381	$491,115

Source: Clean Air Task Force (CATF)

http://www.catf.us/coal/problems/power_plants/existing/

http://www.catf.us/coal/problems/power_plants/existing/Health_Impacts-annual-of_Existing_Plants.xls

http://www.catf.us/coal/problems/power_plants/existing/Toll_from_Coal-Existing_Plants.kmz

Another justification for the assumption that net respending is zero is related to the offsetting nature of pollution controls in different locations, industries and time periods. There is a reasonable expectation that if North Dakota undertakes measures that result in cleaner air in a specific location/industry/time period, the state (and others downwind) will be required to spend less in another location/industry/time period. Moreover, given the current Bakken oil boom, North Dakota has a major new source of emissions, and it is even more plausible that additional pollution controls will be required in the future.[23] So by implementing pollution controls now, North Dakota (and these specific coal-fired plants) can potentially decrease future costs that will be required to reduce emissions. Appendix A provides key citations from Schmalensee and Stavins (2011), who further explore how a key benefit of implementing pollution controls is the avoided cost of implementing other pollution controls.

Finally, these pollution-control expenditures are required so that the two coal plants (which have been very low-cost generation resources)[24] can continue to operate and supply electricity. As noted by the utilities, the two plants have been substantially upgraded over the last several years, such that they can now operate for another 20-30 years.[25] The installation of pollution-control equipment required under the State Implementation Plan has been part of a broader program of life extension and modernization. As such, it is likely that some (and perhaps a sizable portion) of the expenditures that the utilities are attributing to

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[23] "The State has committed to re-evaluating emissions from construction activities related to the oil and gas industry, including construction of oil well pads, compressor stations, and gas plants, in future Regional Haze SIP planning periods since this has the potential to be a growing source category." (76 FR 58638)

[24] Lignite Energy Council (2010b).

[25] According to Basin Electric (2010), "By adding the scrubbers, Leland Olds will be in a better position to operate for an additional 20 to 30 years providing jobs and economic benefits to the area long into the future."

Likewise, Luther Kvernen, Vice President of Generation for Minnkota Power Cooperative, states:

> "The investment in emissions reduction technologies that we are completing now will allow the Young Station to continue to be the major generator for Minnkota's customers for a long time into the future." (Lignite Energy Council, 2010)

pollution controls would have been otherwise required for life extension, even absent any requirements for retrofit of pollution controls.

Given that net respending expenditures are assumed to be zero for the purposes of this study, the employment impacts associated with respending will also be zero, regardless of what respending multiplier (jobs per $) is applied. Put more simply, zero multiplied by any value is still zero. See Appendix B for a discussion of the methodology for modeling the economic development impacts of respending.

IV. Results

A. Selective Catalytic Reduction (SCR)

The EPA's proposed requirement for the installation of Selective Catalytic Reduction for Olds Unit 2 and Young Units 1 and 2 will create 7,700 temporary jobs and 180 permanent new positions. The 7,700 temporary jobs will include a wide range of jobs at the plants, at suppliers and throughout the US economy. The bulk of the jobs will be in North Dakota where the SCR program will result in 5,100 temporary jobs and 130 permanent jobs. Many of the remaining jobs will be filled by workers in Minnesota and other surrounding states. See Exhibit 11 below for Temporary Employment Impacts of SCR Capital Costs.

Exhibit 11: Temporary Employment Impacts of SCR Capital Costs

	Young Units 1 + 2	Olds Unit 2	Total Young + Olds
Project Period	2015-2017	2015-2017	2015-2017
Incremental Capital Expenditures ($ million, 2009 $)[a]	$338	$146	$484
Incremental Capital Expenditures ($ million, 2012 $)[b]	$358	$155	$513
Temporary Employment Impacts			
North Dakota			
Multiplier (Job-Years per $1 million, 2012 $)	10	10	10
Employment (Job-Years)	3,600	1,600	5,100
US outside North Dakota (Minnesota & other)			
Multiplier (Job-Years per $1 million, 2012 $)	5	5	5
Employment (Job-Years)	1,800	800	2,600
Total US			
Multiplier (Job-Years per $1 million, 2012 $)	15	15	15
Employment (Job-Years)	5,400	2,300	7,700

Notes:

[a] Young: 76 FR 58601; Chernick (2011), p. 12;
Olds: 76 FR 58617; Chernick (2011), p. 22.

[b] Costs inflated from 2009 at 2% as assumed in Chernick (2011), pp. 12, 22;
2012 Capital Costs = 2009 Capital Costs x 1.02^3.

The project period for SCR extends from 2015 to 2017. Thus, the employment associated with the Capital Costs for the retrofits (including construction, installation, design, engineering) is temporary. Conversely, the incremental Annual Operations and Maintenance Costs (including repairs, manufacture of consumables and parts) create ongoing jobs. See Exhibit 12 below for Permanent Employment Impacts of SCR O&M Costs.

Exhibit 12: Permanent Employment Impacts of SCR O&M Costs

	Young Units 1 + 2	Olds Unit 2	Total Young + Olds
Incremental Annual Expenditures ($ million, 2009 $)[a]	$19.8	$4.7	$24.5
Incremental Annual Expenditures ($ million, 2012 $)[b]	$21.0	$5.0	$26.0
Permanent Employment Impacts			
North Dakota			
Multiplier (Job-Years per $1 million, 2012 $)	5	5	5
Employment (Job-Years)	100	20	130
US outside North Dakota (Minnesota & other)			
Multiplier (Job-Years per $1 million, 2012 $)	2	2	2
Employment (Job-Years)	40	10	50
Total US			
Multiplier (Job-Years per $1 million, 2012 $)	7	7	7
Employment (Job-Years)	150	30	180

Notes:

[a] Young: 76 FR 58608, 58612; Chernick (2011), pp. 10, 12; Incremental Annual O&M Expenditures are calculated as follows: Average Annual O&M for SCR MINUS Average Annual O&M for SNCR. The formula is applied to the numbers in the exhibit above as follows: Incremental Annual O&M =Average Annual O&M for SCR (Unit 1 $11.3 million, 2009 $ + Unit 2 $17.8 million, 2009 $) - O&M for SNCR ((Unit 1, $3.7 million, 2006 + $ Unit 2, $5.1 million, 2006 $) * ($1.02^3$); costs inflated from 2006 at 2% as assumed in Chernick (2011), p. 10. Olds: 76 FR 58614, 58618; Chernick (2011), p. 22; Incremental Annual O&M = Average Annual O&M for SCR ($7.7 million, 2009 $) – Average Annual O&M for SNCR ($3 million, 2009 $).

[b] Costs inflated from 2009 at 2% as assumed in Chernick (2011), pp. 12, 22; 2012 Incremental Annual O&M Expenditures = 2009 Incremental Annual O&M Expenditures x 1.02^3.

B. State Implementation Plan (SIP)

In addition to the EPA's proposed requirement for SCR, the North Dakota plants have already installed scrubbers (FGD) and other pollution-control measures required by North Dakota in its State Implementation Plan (SIP). The SIP expenditures translate to a significant employment impact in the US as a whole: 12,500 temporary jobs and 950 permanent ones. Again most of these jobs are in North Dakota with 8,400 temporary jobs and 680 permanent ones. See Exhibit 13 for Temporary Employment Impacts of State Implementation Plan Capital Costs.

Exhibit 13: Temporary Employment Impacts of SIP Capital Costs

	Young Units 1 + 2	Olds Units 1 + 2	Total Young + Olds
Project Period	2007-2011	2007-2012	2007-2012
Total Capital Expenditures ($ million)[a]	$425	$410	$835
Temporary Employment Impacts			
North Dakota			
Multiplier (Job-Years per $1 million, 2012 $)	10	10	10
Employment (Job-Years)	4,300	4,100	8,400
US outside North Dakota (Minnesota & other)			
Multiplier (Job-Years per $1 million, 2012 $)	5	5	5
Employment (Job-Years)	2,100	2,100	4,200
Total US			
Multiplier (Job-Years per $1 million, 2012 $)	15	15	15
Employment (Job-Years)	6,400	6,200	12,500

Notes:

[a] Young: Chernick (2011), p. 8; according to Minnkota (2011), p. 2, "in excess of $425 million will be spent on this emission control by the end of 2011." For simplicity, total Capital Costs are assumed to be $425 million in 2012 $.
Olds: Basin Electric (2011) reports projected Capital Cost of $410 million for emission controls to be completed in 2012. For simplicity, total Capital Costs are assumed to be $410 million in 2012 $.

The project period for SIP extends from 2007 to 2012. Thus, the employment associated with the SIP Capital Costs for the retrofits is temporary. Conversely, the incremental Annual Operations and Maintenance Costs create ongoing jobs. See Exhibit 14 below for Permanent Employment Impacts of SIP O&M Costs.

Exhibit 14: Permanent Employment Impacts of SIP Plan O&M Costs

	Young Units 1 + 2	Olds Units 1 + 2	Total Young + Olds
Total Annual Expenditures ($ million, 2012 $)[a]	$32.3	$35.8	$68.1
Permanent Employment Impacts			
North Dakota			
Multiplier (Job-Years per $1 million, 2012 $)	10	10	10
Employment (Job-Years)	320	360	680
US outside North Dakota (Minnesota & other)			
Multiplier (Job-Years per $1 million, 2012 $)	4	4	4
Employment (Job-Years)	130	140	270
Total US			
Multiplier (Job-Years per $1 million, 2012 $)	14	14	14
Employment (Job-Years)	450	500	950

Notes:

[a] Young: Minnkota (2006), Appendix A, p. 3-23; Minnkota (2007), pp. 3-12, 3-21; Chernick (2011), p. 10.
Olds: Basin Electric (2006), pp. 64, 66, 98, 99, 158, 188); Chernick (2011), p. 21; costs inflated from 2005 at 2% as assumed in Chernick (2011), p. 21); 2012 O&M Costs = 2005 Capital Costs x 1.02^7.

C. Summary (SIP & SCR)

Exhibits 15 and 16 provide a breakdown of the temporary and permanent jobs in North Dakota, US outside North Dakota, and the US as a whole for the SIP and SCR programs. These exhibits demonstrate that together the SIP and SCR programs create impressive employment effects in the US. The two programs combined deliver 20,200 temporary jobs and 1,130 permanent jobs to the US economy. Most of these jobs are in North Dakota where the combined SIP and SCR measures will result in 13,500 temporary jobs and 810 permanent ones. These are sizable costs and have sizable job impacts. Moreover, given the current economic downturn and the likelihood of continued high unemployment rates over the next several years, these retrofits represent an excellent and very timely opportunity for North Dakota, neighboring states and the US.

The implementation of the SIP measures over the period of 2007-2012 coincided with a period of deep recession and sluggish recovery. So the timing was excellent for this program to benefit from of slack labor and other productive capacity. Given the continuing slow recovery, marked by high unemployment, the timing is also propitious for the implementation of the SCR measures. While North Dakota may have a low unemployment rate, some of the jobs from the SCR retrofits are out-of-state and some of the in-state jobs may be filled by workers from out-of-state. So the SCR measures will benefit not only the economy of North Dakota, but the economies of neighboring states, and the US as whole.

Appendix A contains key citations from Schmalensee and Stavins (2011), who provide further support as to why a time of high unemployment and sluggish economic recovery is favorable for implementation of pollution controls to meet environmental regulations.

Based on the data from Exhibits 11 and 13, Exhibit 15 provides a Summary of Temporary Employment Impacts of SIP & SCR Capital Costs.

Exhibit 15: Summary of Temporary Employment Impacts of SIP & SCR Capital Costs

	Young	Olds	Young + Olds
Capital Expenditures ($ million, 2012 $)			
State Implementation Plan (SIP)	$425	$410	$835
Selective Catalytic Reduction (SCR)	$358	$155	$513
Total (SIP + SCR)	$783	$565	$1,348
Temporary Employment Impacts in North Dakota			
Multiplier (Job-Years per $1 million, 2012 $)	10	10	10
Annual Employment Impacts			
State Implementation Plan (SIP)	4,300	4,100	8,400
Selective Catalytic Reduction (SCR)	3,600	1,600	5,100
Total (SIP + SCR)	7,900	5,700	13,500
Temporary Employment Impacts in US outside ND			
Multiplier (Job-Years per $1 million, 2012 $)	5	5	5
Annual Employment Impacts			
State Implementation Plan (SIP)	2,100	2,100	4,200
Selective Catalytic Reduction (SCR)	1,800	800	2,600
Total (SIP + SCR)	3,900	2,800	6,700
Temporary Employment Impacts in Total US			
Multiplier (Job-Years per $1 million, 2012 $)	15	15	15
Annual Employment Impacts			
State Implementation Plan (SIP)	6,400	6,200	12,500
Selective Catalytic Reduction (SCR)	5,400	2,300	7,700
Total (SIP + SCR)	11,700	8,500	20,200

Based on the data from Exhibits 12 and 14, Exhibit 16 provides a Summary of Permanent Employment Impacts of SIP & SCR O&M Expenditures.

Exhibit 16: Summary of Permanent Employment Impacts of SIP & SCR O&M Costs

	Young	Olds	Young + Olds
Annual O&M Expenditures ($ million, 2012 $)			
State Implementation Plan (SIP)	$32	$36	$68
Selective Catalytic Reduction (SCR)	$21	$5	$26
Total (SIP + SCR)	$53	$41	$94
Temporary Employment Impacts in North Dakota			
Multiplier (Job-Years per $1 million, 2012 $)			
State Implementation Plan (SIP)	10	10	10
Selective Catalytic Reduction (SCR)	5	5	5
Total (SIP + SCR)	8	9	9
Annual Employment Impacts			
State Implementation Plan (SIP)	320	360	680
Selective Catalytic Reduction (SCR)	100	20	130
Total (SIP + SCR)	430	380	810
Temporary Employment Impacts in US outside ND			
Multiplier (Job-Years per $1 million, 2012 $)			
State Implementation Plan (SIP)	4	4	4
Selective Catalytic Reduction (SCR)	2	2	2
Total (SIP + SCR)	3	4	3
Annual Employment Impacts			
State Implementation Plan (SIP)	130	140	270
Selective Catalytic Reduction (SCR)	40	10	50
Total (SIP + SCR)	170	150	320
Temporary Employment Impacts in Total US			
Multiplier (Job-Years per $1 million, 2012 $)			
State Implementation Plan (SIP)	14	14	14
Selective Catalytic Reduction (SCR)	7	7	7
Total (SIP + SCR)	11	13	12
Annual Employment Impacts			
State Implementation Plan (SIP)	450	500	950
Selective Catalytic Reduction (SCR)	150	30	180
Total (SIP + SCR)	600	530	1,130

Appendix A: Economic Analysis of EPA Air Quality Regulation

"A Guide to Economic and Policy Analysis of EPA's Transport Rule" by Schmalensee and Stavins (2011) provides a very useful framework for analysis of EPA Air Quality Regulation. The specific focus of this guide is EPA's Clean Air Transport Rule (Transport Rule).[26] But this guide is more generally applicable to EPA Air Quality Regulation, and especially rules affecting the electric power sector. In particular, this guide is well suited for analysis of EPA's Regional Haze Program and the pollution control retrofits at the Milton R. Young and Leland Olds Plants being considered in this study,

The remainder of this appendix is an excerpt from Schmalensee and Stavins (2011), specifically the portion of Section IV. Distributional Economic Impacts on pp. 24-26.

B. Economic Growth and Employment

With today's high unemployment rates and sluggish economic recovery, policymakers and the public are particularly interested in the job effects of new environmental regulations. Will new regulations create or destroy jobs? Where and in what sectors?

In good economic times, when the workforce is fully or almost fully employed, using labor to meet new regulatory requirements both raises the costs of regulated goods and means that fewer workers are available to do other productive things in the economy. By diverting scarce labor resources away from other activities, the use of labor thus imposes an opportunity cost on society, which should be considered alongside the capital costs of pollution reduction.

However, in difficult economic times, such as today's, when unemployment is high, some workers used to meet new regulatory requirements may have otherwise been

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[26] 75 FR 45210-45465.

unemployed or underemployed. Thus, using their labor to implement the regulation imposes lower costs on society. Moreover, through indirect effects, environmental regulation may spur economic activity and job growth in sectors not directly affected by the regulation, but which provide goods and services for those sectors.

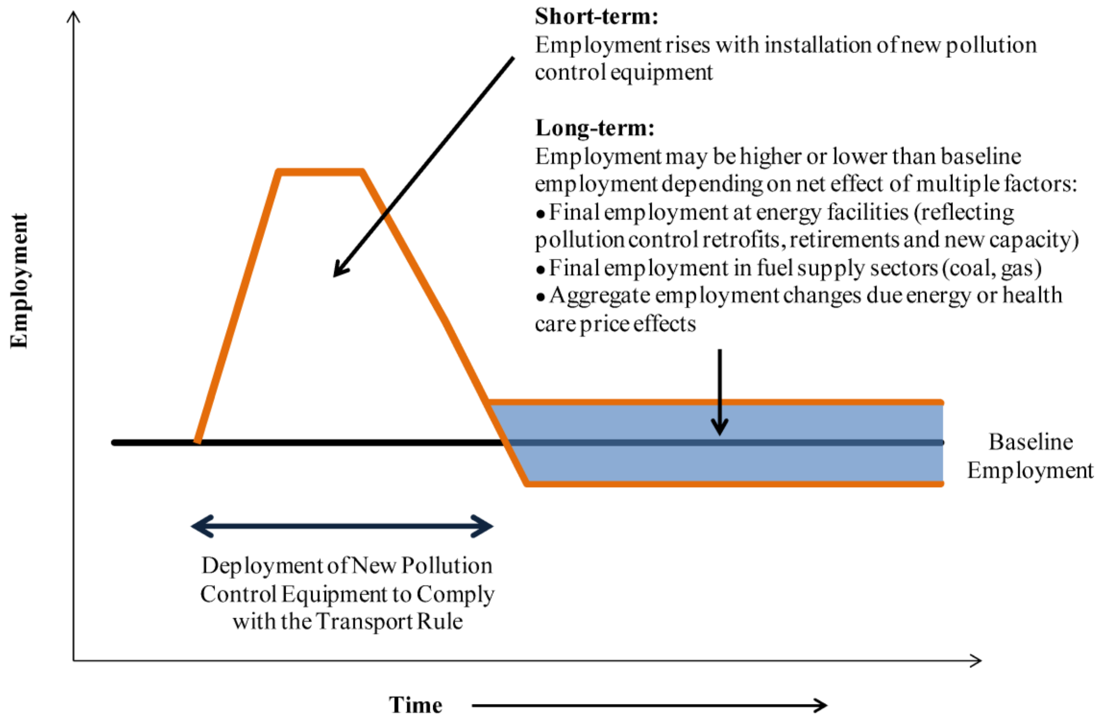
The mechanisms that drive job impacts reflect the various economic adjustments made in response to the new regulations. Direct responses to regulation will lead to short-term job gains from the manufacture and installation of new pollution control equipment to comply with the regulation. In the long run, adjustments in employment will depend upon how the power sector industry adjusts to the new regulatory requirements, as well as the indirect upstream and downstream effects of those adjustments on the rest of the economy. These direct and indirect impacts can vary in their magnitude over time, and across regions and sectors.

The particular nature of the regulation can also affect employment impacts. Since environmental improvements are often achieved through regulations on multiple entities in multiple locations, more stringent regulations in one location potentially may relax regulatory requirements on other entities in other locations. For example, by reducing emissions from upwind sources, and helping downwind regions attain NAAQS compliance, the Transport Rule may relax regulatory requirements on sources in those downwind regions.

Moreover, because these various adjustments can lead to many *offsetting* direct and indirect effects, which can vary across regions and sectors, determining the net employment effect is challenging. Consequently, estimates of partial or localized employment effects can paint an inaccurate picture of net employment impacts if not properly placed in a broader economic context.

Employment impacts from the Transport Rule are also likely to vary significantly over time. In the short run, compliance with the Transport Rule will likely lead to short-term job gains arising from the design, manufacture and installation of pollution controls.[27] Various estimates of the employment impacts associated with infrastructure installation suggest that these impacts could be significant with a large share of these immediate job gains occurring in regions where new equipment is installed. Moreover, while these job impacts would be temporary, they could also stimulate the broader economy and employment.

Exhibit 17: Illustrative Employment Impacts of the Transport Rule
[Figure 6 in original Schmalensee and Stavins (2011)]



Note: The figure provides a stylized depiction of Transport Rule employment impacts and does not reflect a quantitative assessment, such that the relative magnitude of depicted impacts reflects likely impacts.

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[27] [Footnote 68 in original] The installation of pollution-control technology may require a substantial amount of labor relative to the number of employees otherwise working at a power plant. For example, one study estimates that the manufacture and installation of FGD creates employment of 848-1,001 annual full-time equivalents (Industrial Economics, 2010). Assuming two years to install the unit, this means about 400 to 500 jobs. This same study estimates that 103 permanent workers are needed to operate and maintain this equipment. By contrast, the National Commission on Energy Policy found that 1 GW of coal-fired capacity requires 100 to 300 employees. See Price, Jason *et al.*, "Employment Impacts Associated with the Manufacture, Installation, and Operation of Scrubbers," Industrial Economics Memorandum, January 15, 2010; National Commission on Energy Policy's Task Force on America's Future Energy Jobs, Final Report.

While employment is likely to rise in the short run, in the long run, employment could either increase or decrease depending on direct changes in electricity generation, indirect effects as these changes ripple through the economy, and the relaxation of regulatory requirements as downwind regions come into NAAQS compliance. These impacts would also vary significantly across regions. In upwind regions subject to the Transport Rule, while some employment may be lost as a consequence of coal-fired generation retirements, these losses will be offset – at least partially and potentially more than fully – by employment gains from operating pollution control equipment and staffing the new generation facilities needed to replace any retired capacity.

In “downwind” regions, employment may rise as the Transport Rule brings these regions into attainment with NAAQS, thus allowing them to relax the more stringent emission standards imposed on non-attainment regions.[28] For example, new stationary sources in noncompliance regions must meet standards based on the Lowest Achievable Emission Rate (LAER), which are more stringent than the alternative Best Available Control Technology (BACT) standards. In addition, new sources in nonattainment regions must offset all (or even more than all) emissions through the purchase of emission offsets. The aggregate and cumulative effect of these more stringent requirements can be significant.[29]

In addition to relaxing existing requirements in noncompliance regions, the Transport Rule can also avoid the need to impose further requirements in these regions to help bring them into compliance. Moreover, the costs of achieving emission reductions through the Transport Rule are generally less costly than alternatives measures targeting non-electricity in-state sources. For example, EPA notes that the cost of SO_2 reductions

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[28] [Footnote 69 in original] *See*, Cicchetti, 2010, pp. 33-35.

[29] [Footnote 70 in original] Greenstone estimates that counties out of attainment with the CAA lost approximately 590,000 jobs and $127 billion ($2009) in output over the first 15 years of implementation of the CAA (compared to counties in compliance with the CAA.) Greenstone, Michael, “The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufacturers,” *Journal of Political Economy* 100(6). *See, also* Becker, Randy and Vernon Henderson, “Effects of Air Quality Regulations on Polluting Industries,” *Journal of Political Economy* 108(2):379-421.

by non-electricity sources ranges from \$2,270 to \$16,000 per ton of SO_2, compared to a maximum of \$2,000 per ton for upwind electricity sources.[30] These differences in the cost-effectiveness of alternative means of reducing emissions not only have distributional consequences across regions, but also have consequences for aggregate national costs of bringing all regions into compliance with air quality standards.[31]

In addition to these direct effects on upwind and downwind regions, the Transport Rule could lead to job impacts through the price effects identified in earlier sections. For example, the Transport Rule would likely raise prices for electricity (particularly in regions heavily reliant on coal), and lower prices for health insurance by varying degrees across eastern states. The net impact of these adjustments on any given state is unclear, may vary across industries depending on the intensity of their electricity use, but is likely to be limited given the small price changes anticipated as a consequence of the Transport Rule.

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[30] [Footnote 71 in original] F.R. Vol. 75, No. 147, p., 45281.

[31] [Footnote 72 in original] Any conclusions about cost-effectiveness of alternative approaches to emission reductions must reflect differences in the benefits created by reducing emissions from alternative sources given each source’s specific geographic location and the air transport of emissions to downwind populations.

Appendix B: Comparison with Other Studies

A. Review of Other Analyses

Numerous analyses have been undertaken to examine the employment impacts of pollution-control expenditures. TGG has reviewed three main groups of employment analyses:

1. Utility reports for labor requirements associated with a project
2. Estimates of jobs based on expenditure mix and labor requirements
3. Other Input-Output Analyses.

The following sections discuss and evaluate each group of analyses.

1. Utility Reports for Labor Requirements

Typically these reports estimate the labor force associated with a construction project. The objective of these reports is construction management and therefore the focus is generally the installation labor by on-site contractors. These estimates, by themselves, are incomplete and problematic for use in estimating the total job impacts of the pollution-control equipment expenditures for two main reasons.

First, the estimates of labor requirements provided by the utility are only a subset of the total direct and indirect jobs (and fail to even consider the induced jobs). Typically, these estimates do not include the labor of utility employees involved in the project. Usually utility employees have some involvement in the project in terms of permitting and PMEC (project management, engineering, construction management).[32]

Second, the utility estimates for on-site installation labor are generally expressed in terms of peak requirements (maximum number of on-site contractors needed during the project) and not job-years. As defined above, one job-year is

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[32] Exhibit 5 and Cichanowicz 2010 provide additional information regarding the scope of utility reports on project cost and labor requirements.

equivalent to one full-time job for one person for one year. Employment impacts are typically expressed in job-years, a metric that provides a more accurate description of the job impacts of a project over its lifespan.

2. Job Estimates Based on Expenditure Mix and Labor Requirements

These estimates are generally produced through focused research (including by the EPA and EPA contractors in the pollution-control industry, as well as individual companies and trade associations). This research is in part undertaken to evaluate the feasibility and possible bottlenecks for pollution-control retrofits. This exercise is important because the EPA mandates can trigger many retrofits throughout the US that must be undertaken within a given period.[33]

As is the case with the estimates from the utility reports, these research-based estimates, by themselves, are incomplete with respect to the total employment impacts. While these estimates also focus on on-site installation labor, they do trace other visible economic and geographic linkages that are pertinent to the interests of the pollution-control industry and relate to bottlenecks. So while these estimates consider a broader range of employment impacts than the utility reports, they fail to consider a wide range of job impacts of pollution-control expenditures. These research-based estimates provide a good point of reference with which to check and validate other results.

3. Other Input-Output Analyses

TGG also conducted a literature review of other Input-Output analyses with a particular focus on analyses that related to the employment impacts of pollution-control retrofits.

We found two studies to be highly relevant to our analysis:

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[33] According to the pollution-control industry, bottlenecks are not a concern and the EPA demand for retrofits will continue to be met.

1. The PERI analysis (Heintz, 2011), an independent study of the effects of proposed EPA retrofits across the US, including North Dakota. PERI reviewed four different pollution-control technologies in all states where they might be required.
2. Shapiro et al 2009, a REMI-based[34] analysis of an FGD retrofit for a coal-fired plant in New Hampshire. This study not only used REMI, but also was conducted on behalf of a utility, which generally implies high-quality data in the form of detailed expenditure breakdowns.

In addition, TGG's literature review of other Input-Output analyses focused on analyses that related to the employment impacts of energy-related and other economic activities in North Dakota. The North Dakota State University (NDSU) Department of Agribusiness and Applied Economics has developed and maintains a North Dakota Input-Output model.[35] This model has been used since 1982 to produce annual economic studies of the lignite industry on behalf of the Lignite Energy Council.[36]

The North Dakota State University (NDSU) Department of Agribusiness and Applied Economics has also developed and maintains several other North Dakota economic models that have been used to produce studies of the employment and other impacts associated with the energy sector including those of lignite and wind power.[37]

These studies and several others assisted us in the development of inputs for the Input-Output model and provided a check of reasonableness for the results.

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[34] REMI is a high-quality Input-Output based model, which also incorporates aspects of three other major modeling approaches: General Equilibrium, Econometric, and Economic Geography. See < http://www.remi.com/index.php?page=model&hl=en_US >.

[35] Coon et al 1985; Coon and Leistritz (2009a).

[36] See Footnote 5.

[37] Leistritz and Coon (2008); Leistritz et al (1982).

B. Why the Input-Output Model Is the Best-Suited

Each of the three groups of analyses considered above has advantages and drawbacks. The utility labor requirements estimates provide a limited number of onsite jobs that are relatively easy to measure. Then the research-based estimates derived from expenditure mix and labor requirements consider broader impacts both in terms of economic linkages and geography. Finally, the Input-Output model’s estimates take into account a wide range of job impacts (direct, indirect and sometimes induced), but the application of the model requires more judgment, approximation and estimation. So as we move from the utility estimates to Input-Output estimates, we take into account broader and broader sets of economic and geographic linkages, but as we go broader, there is more judgment, approximation and estimation involved.

TGG has reviewed a large number of different employment analyses, including our own, to explore how experts address this issue. We note that different kinds of analyses are undertaken for different purposes with different methodologies and scopes with respect to the geographic and economic linkages that are considered.

As indicated in Section II, TGG has concluded from its extensive review of numerous groups of analyses that the Input-Output model, done well and carefully, is best-suited to estimate the employment impacts in this study for two main reasons. One, the model takes into account a wide range of effects in the estimation of the employment impacts for the North Dakota pollution controls – and thus provides the most realistic overall results. Two, Input-Output is a very strong tool that models regional employment impacts and provides high-quality multipliers that are well-tailored to specific expenditures. However, care must be taken in applying the model and additional effort must go into the customization of this model for the pollution-control retrofits in this study.

Section III.B discussed how TGG was able to handle the two important challenges in the judicious application of an Input-Output model in this study: (i) the highly complex and heterogeneous nature of these pollution-control retrofits;

and (ii) the availability of detailed expense breakdowns from the utilities. Moreover, other groups of analyses (i.e. utility estimates, estimates of jobs based on expenditure mix and labor requirements and the results of other Input-Output studies) are also very useful, both in the development of inputs, and as a check of reasonableness for the results.

Appendix C: Modeling Economic Development Impacts of Respending

In this study, net respending expenditures are assumed to be zero. As such, the employment impacts associated with respending will also be zero, regardless of what respending multiplier (jobs per $) is applied. Put more simply, zero multiplied by any value is still zero.

Respending can be an issue of substantial importance in some analyses.[38] So guidance is provided in this Appendix regarding how to model the economic development impacts associated with this respending.

For residential energy users, it is reasonable to assume that they will respend (respond to energy and other cost changes) similarly to how they generally spend money, i.e., on a wide mix of consumer goods and services, with some assigned to savings. And because much of consumer spending goes to local businesses (such as restaurants), it produces a substantial amount of in-state jobs per dollar. So within Input-Output modeling, residential energy cost savings can be analyzed as household/personal consumption expenditures.

But in North Dakota and other states, commercial and industrial (C&I) customers account for a large portion of energy usage and any cost changes associated with energy options. And compared with the case of residential customers, it is much harder to estimate the effect of energy and other cost changes on C&I customers and where respending will be directed. Some of these changes may result in changes to profits, and these profits will flow to business owners, who may or may not be in-state. Some of these changes may affect prices for the C&I customers' products, and the impacts of these price changes will flow to in-state purchasers of these products, as well as out-of-state consumers.

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[38] Respending typically accounts for a large portion of the overall economic development impacts estimated for energy efficiency programs. Such programs are often highly cost-effective, such that their overall impact is to significantly reduce consumers' energy costs.

Of course, if the C&I customers change their prices, this might affect demand for whatever they are producing. And this could lead to changes in production either in-state or outside in response to changes in demand. And the C&I customers might make changes in the amount of investments undertaken to upgrade and expand their facilities (in-state and outside), to satisfy demand (as affected by price changes) or in pursuit of other corporate goals.

The description above deals with for-profit businesses, and the C&I sector also includes government (public sector entities), and institutions (such as universities) and other non-profits. But in broad terms, the description above does capture the range of how any C&I customer might react to changes in energy and other costs (e.g., government could react to lower costs by expanding services, reducing debt, or by reducing taxes).

In advance (or even after the fact), it can be difficult to determine how C&I customers react to changes in energy and other costs. Input-output models (such as IMPLAN and US Department of Commerce RIMS) do not provide any direct mechanisms or guidance as to how to analyze respending of energy and other cost changes by C&I customers. In previous studies relying upon these kinds of Input-Output models, TGG has calculated the economic development impacts for respending by C&I customers based on multipliers for capital spending (new plant and equipment). The multipliers for such spending are intermediate between the results for various assumptions regarding the possible impacts of such respending, and as such, appear reasonable (and possibly conservative).

To summarize, TGG has used the following methodology to analyze respending in previous studies. C&I energy cost savings are modeled as capital spending (new plant and equipment), and residential savings as household/personal consumption expenditures. The modeling of respending is tailored to reflect state-specific factors (notably the allocation of respending between residential and C&I customers).

Applying the above methodology to North Dakota results in an Employment multiplier (for the mix of residential and C&I respending) that is within the range of typical Employment multipliers for expenditures on pollution controls and other energy sector expenditures. Compared with the specific pollution-control expenditures analyzed in this study, respending by North Dakota customers is estimated to have a similar, but somewhat higher Employment multiplier.

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Abbreviations and Acronyms

The following abbreviations and acronyms are used in this work, in cited works, or in the field generally.

AFUDC	Allowance for Funds Used During Construction
APC	Air Pollution Control
ASOFA	Advanced Separated Overfire Air
BART	Best Available Retrofit Technology
DOE	Department of Energy
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
FGD	Flue-gas desulfurization, also known as scrubbing
FR	Federal Register
G&T	Generation-and-transmission
IPM	Integrated Planning Model
kV	kilovolts
MW	Megawatt, a unit of generating capacity
MWh	Megawatt hour, a unit of electricity production or consumption
NDDH	North Dakota Department of Health
NIPCo	Northwest Iowa Power Co-operative
NMPA	Northern Municipal Power Agency
NO_X	Oxides of nitrogen (nitrogen oxides)
NSR	New Source Review provisions of the Clean Air Act
O&M	Operation-and-maintenance
$PM_{2.5}$	Particulate matter with diameters less than 2.5 microns (micrometers)
PM_{10}	Particulate matter with diameters less than 10 microns (micrometers)
REMA	Rural Electric Management Association
RUS	U.S. Rural Utility Service, formerly the Rural Electrification Administration
SCR	Selective catalytic reduction
SIP	State Implementation Plan
SNCR	Selective Non-Catalytic Reduction
SO_2	Sulfur dioxide
SOFA	Separated Overfire Air
WAPA	Western Area Power Administration