IEc

MEMORANDUM | 31 March 2011

TO Ellen Kurlansky

FROM Jason Price, Nadav Tanners, and Jim Neumann (IEc) and Roy Oommen (ERG)

SUBJECT Employment Impacts Associated with the Manufacture, Installation, and Operation of Scrubbers

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INTRODUCTION

EPA expects that a wide range of current and upcoming regulatory actions pursued under the authority of the Clean Air Act (CAA) could significantly increase the demand for flue gas desulfurization (FGD, commonly referred to as scrubbers). Under the combined requirements of more stringent NAAQS standards, regional haze requirements, a revised Clean Air Interstate Rule, and Section 112 MACT rules, FGD may be the most cost-effective compliance strategy for affected emissions sources. Therefore, a full understanding of the economic impacts associated with the manufacture, installation, and operation of scrubbers is critical to an assessment of the impacts of these rules. Among these impacts is the employment effect associated with the production, installation, and operation of scrubbers in response to CAA requirements.

The purpose of this memorandum is to present the average employment impacts associated with the manufacture, installation, and operation of a scrubber. These per-scrubber employment impacts may inform the assessment of regulatory impacts for upcoming CAA regulations. The employment impacts estimated in this memorandum include both direct and indirect impacts. Direct employment impacts include labor used by scrubber manufacturers, fabricators, and users, whereas indirect impacts include labor employed in the production of inputs to scrubber production, as well as labor employed by vendors that support scrubber operations.

We estimate employment impacts for a series of model scrubber installations, defined in terms of their size and application (e.g., electric utilities versus industrial boilers). Exhibit 1 summarizes our employment estimates for each model scrubber. As indicated in the exhibit, employment impacts are most significant for large scrubbers installed at electric utilities.

In the sections that follow, we provide a detailed specification of the model scrubbers that we used for this analysis, summarize our methods for estimating the direct and indirect employment impacts for each model scrubber, and present recommendations for applying our results in a regulatory setting.

EXHIBIT 1. SUMMARY OF EMPLOYMENT IMPACTS PER MODEL SCRUBBER

MODEL SCRUBBER	MODEL SCRUBBER DESCRIPTION	ONE-TIME EMPLOYMENT IMPACTS (ANNUAL EQUIVALENT FTEs)[2]	RECURRING ANNUAL EMPLOYMENT IMPACTS (FTEs PER YEAR)[3]
Model Scrubber 1	Medium/Large Utility Boilers	848 – 1,001	103
Model Scrubber 2	Small Utility Boilers	409 – 493	39
Model Scrubber 3A[1]	Large Industrial/ Institutional Boilers (method 1)	333 – 400	29
Model Scrubber 3B[1]	Large Industrial/ Institutional Boilers (method 2)	77 - 91	16
Model Scrubber 4	Small- and Medium-Sized Industrial/Institutional Boilers	40 – 48	6

Notes:

1. As described in later sections of this document, Model Scrubbers 3A and 3B are different analytic variants of the same model scrubber. Both represent scrubbers at large industrial boilers, but we estimate employment impacts for Model Scrubber 3A based on one methodology and Model Scrubber 3B based on another.
2. One-time employment impacts reflect the labor required for the manufacturing and installation of each model scrubber, including the labor required to produce scrubber components (e.g., the absorber vessel) that scrubber makers purchase from other firms.
3. Recurring employment impacts include labor required for the operation, maintenance, and administrative support for each scrubber over its full lifetime of operation.

MODEL SCRUBBERS

The guiding principles that informed the specification of model scrubbers for this analysis were to (1) capture the range of scrubbers likely to be installed in response to various emissions control requirements and (2) reflect significant per-scrubber employment impact variation. To that end, we define the model scrubbers for this analysis in terms of their size (i.e., capacity of the controlled combustion unit) and the type of boiler to which each scrubber is applied for acid gas control. We distinguish between scrubbers at electric utilities and scrubbers installed on industrial/ institutional boilers because of the significant differences between the two in terms of construction and labor requirements.[1] The scrubber market is similarly segmented along these lines, such that many companies that manufacture large scrubber units for utilities do not manufacture scrubbers for smaller industrial sources and *vice versa*.

[1] In addition, as indicated below, installation represents most of the direct one-time labor associated with EGU scrubbers, whereas manufacturing makes up most of the direct one-time labor associated with industrial boiler scrubbers.

MODEL SCRUBBERS FOR ELECTRIC UTILITIES

We define the model scrubbers for electric utilities based on a prior ERG analysis. For Alberta's Clean Air Strategic Alliance, ERG conducted a review of the USEPA Clean Air Market Division's database and specified three model units defined in terms of their size: small (25-100 MW), medium (100-500 MW), and large (> 500 MW).[2] ERG's analysis of wet FGD systems for these units identified a clear difference in the capital cost per energy output ($/MW) between wet FGD systems applied to small utility units (25 - 100 MW) and those applied to medium to larger units (100 – 1,000 MW). Assuming that this difference in capital costs is indicative of differences in labor requirements, we specify two model scrubbers consistent with these capacity ranges, as indicated in Exhibit 2.

MODEL SCRUBBERS FOR INDUSTRIAL BOILERS

The model scrubbers for industrial boilers are based on EPA's previous analysis of the costs associated with the MACT standards for these sources. To estimate the costs of the industrial boiler MACT, EPA specified a series of model units based on Federal and state databases and survey data compiled by the Agency for these units.[3] These model units were differentiated by size (as well as other factors not relevant to this analysis) into the following categories: < 10 million Btu per hour (MMBtu/hr), 10-100 MMBtu/hr, 100-250 MMBtu/hr, and > 250 MMBtu/hr. EPA's assessment of the scrubber-related costs for these model units found a significant difference in total annualized cost between units with capacity greater than 250 MMBtu/hr—most of which burned coal as their primary fuel—and those with capacity less than 250 MMBtu/hr—most of which used residual fuel oil or process gas as their primary fuel. This difference in costs reflects: (1) higher flue gas flow rates from larger units that will require larger control devices, and (2) high pollutant concentrations in coal relative to residual fuel oil or process gas, requiring more expensive controls with higher reduction efficiencies. Assuming that this difference in costs is indicative of differences in labor requirements, we specify two model scrubbers for units installed at industrial/institutional boilers: one for scrubbers installed at small- and medium-sized industrial boilers (50-250 MMBtu/hr) and a second for scrubbers at large industrial boilers (250-500 MMBtu/hr), as shown in Exhibit 2.

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[2] ERG, Electricity Framework 5 Year Review – Control Technologies Review. Final Report. Prepared for Clean Air Strategic Alliance of Alberta, Canada. January 21, 2009.

[3] A summary of these units is available in Jeanette Alvis Christy Burlew, and Roy Oommen, Eastern Research Group. "Development of Model Units for the Industrial/ Commercial/ Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants". Memorandum to Jim Eddinger, U.S. EPA. October 2002.

EXHIBIT 2. SUMMARY OF MODEL SCRUBBERS

MODEL NO.	BOILER TYPE/APPLICATION	BOILER SIZE (IN TYPICAL UNITS FOR APPLICATION)	BOILER SIZE (STANDARDIZED TO MMBTU/HR)
1	Utility Boilers (Medium and Large)	100–1,000 MW	980-9,800 MMBtu/hr
2	Utility Boilers (Small)	25-100 MW	245 -980 MMBtu/hr
3	Industrial/Institutional Boilers (Large)	250-500 MMBtu/hr	250-500 MMBtu/hr
4	Industrial/Institutional Boilers (Small- and Medium-Sized)	50-250 MMBtu/hr	50-250 MMBtu/hr

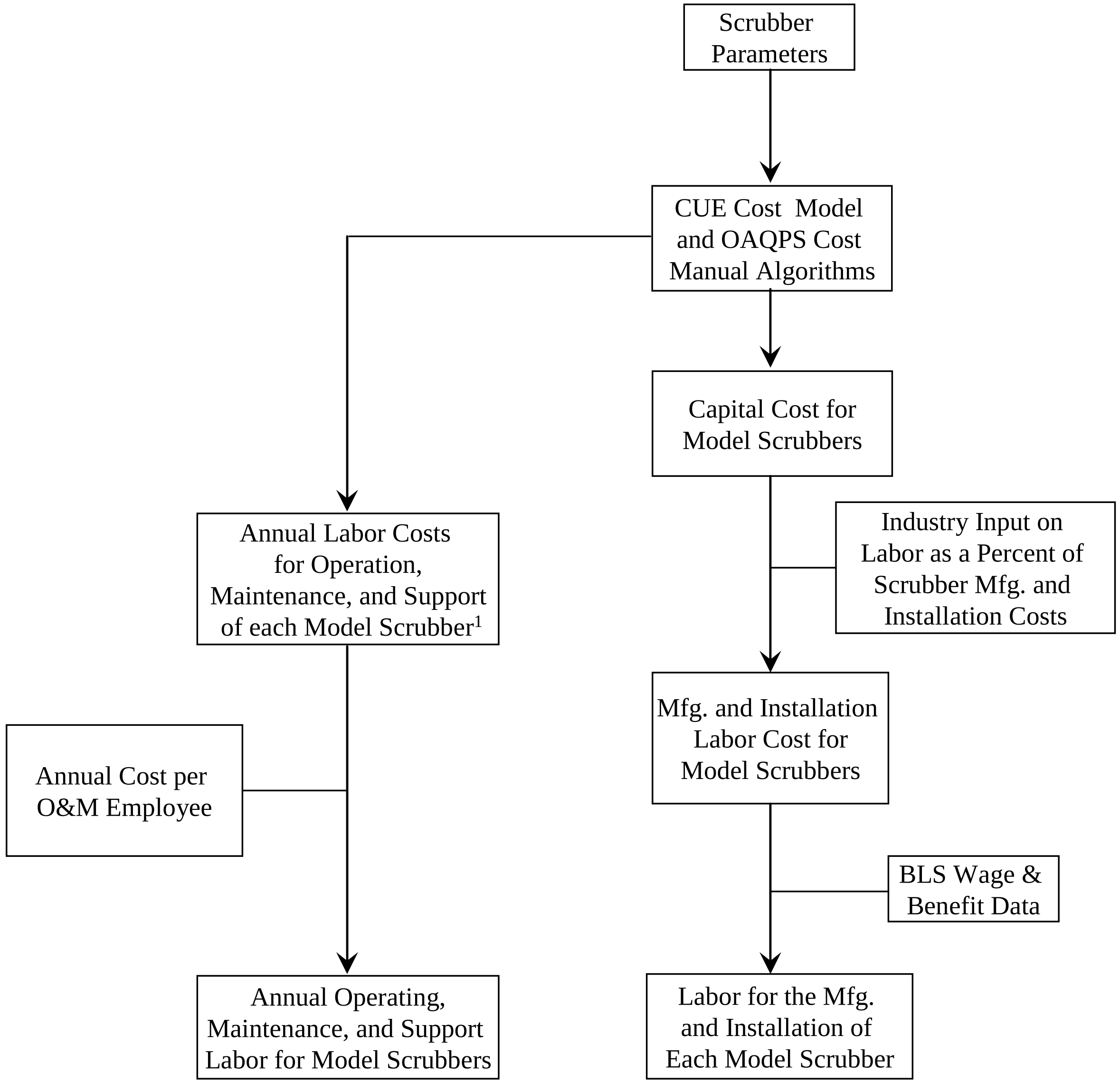
DIRECT EMPLOYMENT IMPACTS

In this section, we present our analysis of the direct employment impacts associated with scrubber manufacturing, installation, and operation. These direct impacts include labor expended by scrubber producers for the manufacturing and installation of scrubbers and the labor required (on an annual basis) for the operation of a scrubber. We note that these direct employment impacts do not include labor associated with the production of material inputs used (purchased) by scrubber manufacturers or labor employed by vendors that support scrubber operations (e.g., firms that assist with FGD gypsum disposal).

As indicated above, the model scrubbers specified for this analysis distinguish between scrubbers at electric utilities and scrubbers at industrial boilers. Because electric generating units (EGUs) are typically much larger than industrial boilers and can more easily realize economies of scale, electric utilities often construct scrubber support systems on-site, such as more complex waste handing and disposal systems, reagent handling systems, and limestone grinding systems. Industrial sources generally rely upon external vendors for these support functions. Large industrial boilers, which are similar in size to small utility units, may use either method depending on the cost over the lifetime of the equipment. To address this uncertainty, we estimate employment impacts for large industrial boilers (Model Scrubber 3) using two methodologies: one in which we assume that large industrial units construct scrubber support systems onsite and another in which we assume that these units rely on external vendors for this support. For reporting purposes, we designate the former as Model Scrubber 3A and the latter as Model Scrubber 3B.

Exhibit 3 summarizes the approach that we employed to estimate the direct employment impacts associated with the manufacture, installation, and operation of each model scrubber. As indicated in the exhibit, the main steps of our approach are as follows:

EXHIBIT 3. SCHEMATIC OF METHODOLOGY FOR ESTIMATING DIRECT SCRUBBER LABOR REQUIREMENTS



1. For the operator labor associated with EGU model scrubbers, the CUECost program directly estimates the annual number of FTEs. Maintenance and administrative support labor for EGU model scrubbers is estimated based on the approach depicted in this exhibit.

1. Input model scrubber parameters into EPA's CUECost Program (for scrubbers at EGUs) and the cost algorithms included in the OAQPS control cost manual (for industrial boiler scrubbers) to estimate the capital costs associated with each model scrubber.[4],[5]

2. Based on industry input on the labor costs reflected in the total cost of a scrubber, estimate the labor costs associated with the manufacture and installation of each model scrubber.

3. Using wage and fringe benefit data from the Bureau of Labor Statistics (BLS), translate manufacturing and installation labor costs for each model scrubber into estimates of the labor required for manufacturing and installation, measured as full-time equivalents (FTEs).

4. Estimate operating and maintenance labor based on O&M data generated by CUECost and the OAQPS cost manual algorithms. We generate separate estimates for operator labor, maintenance labor, and administrative support labor.

We discuss each component of the analysis in greater detail below.

ESTIMATION OF SCRUBBER CAPITAL COSTS

The first step in our assessment of direct labor requirements is to estimate the total investment cost (i.e., upfront capital cost) for each model scrubber. For scrubbers at electric utilities, we generate these estimates with EPA's CUECost program, whereas our estimates for industrial boiler scrubbers are based on the cost algorithms contained in the OAQPS control cost manual. The CUECost program was developed by EPA for analysis of the costs associated with nitrous oxide (NO_x), sulfur dioxide (SO_2), and particulate matter (PM) controls at coal-fired utility boilers. The OAQPS control cost manual provides detailed information on point source and stationary area source air pollution controls for volatile organic compounds (VOCs), PM, NO_x, SO_2, and other acid gases.

Estimation of the capital costs for each model scrubber requires the specification of data inputs for the CUECost Program and the algorithms contained in the OAQPS control cost manual. In particular, representative capacity and SO_2 control efficiency values were necessary for each model scrubber. Based on our previous experience with electric utility and industrial boilers scrubbers, we selected the representative capacity values included in Exhibit 4. The control efficiency for scrubbers may range from 90 to 99 percent. For this analysis, we assumed a control efficiency of 95 percent. For other data inputs required by CUECost (e.g., coal type and properties, flue gas temperature, etc.), we used the default values included in the program. Similarly, for other data inputs required by

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[4] Detailed information on the CUECost Program is available in R. Keeth, R. Blagg, C. Burklin, B. Kosmicki, D. Rhodes, and T. Waddell, *Coal Utility Environmental Cost (CUECost) Workbook User's Manual Version 1.0*, prepared for U.S. EPA. Information on the OAQPS cost algorithms is available in U.S. EPA, OAQPS, *EPA Air Pollution Control Cost Manual*, Sixth Edition, January 2002.

[5] Capital costs for Model Scrubber were estimated with both CUECost and the OAQPS cost algorithms.

the cost algorithms contained in the OAQPS cost manual (e.g., temperature, inlet sulfur loading, etc.), we used default inputs previously developed by ERG for another analysis.[6]

EXHIBIT 4. REPRESENTATIVE CAPACITY FOR EACH MODEL SCRUBBER

MODEL NUMBER	SIZE RANGE	TYPICAL SIZE (IN TYPICAL UNITS FOR APPLICATION)	TYPICAL SIZE (STANDARDIZED TO MMBTU/HR)
1	100 MW – 1,000 MW	750 MW	7,350 MMBtu/hr
2	25-100 MW	100 MW	980 MMBtu/hr[a]
3A and 3B	250 – 500 MMBtu/hr	500 MMBtu/hr	500 MMBtu/hr
4	50 – 250 MMBtu/hr	100 MMBtu/hr	100 MMBtu/hr

Based on the inputs entered into CUECost and the OAQPS cost manual algorithms, we estimate that the capital costs for the model scrubbers range from $7.1 million for small scrubbers installed on industrial boilers to $116 million for scrubbers fitted to large EGU boilers, as indicated in Exhibit 5.

ESTIMATION OF DIRECT LABOR COSTS FOR THE MANUFACTURE AND INSTALLATION OF EACH MODEL SCRUBBER

A key step in our assessment of direct scrubber employment impacts is estimation of the labor costs reflected in the total capital cost associated with each model scrubber. These labor costs reflect the cost of employing engineers, iron and steel workers, and boilermakers to manufacture and install each scrubber. Based on input from various industry sources, we estimate these labor costs as a percentage of the total investment costs for each model scrubber. Exhibit 6 summarizes the estimates that we obtained from these sources. As the exhibit indicates, the estimates that we obtained vary significantly, ranging from 25 percent of capital costs to 50 percent. However, most of the scrubber manufacturers and installers included in Exhibit 6 indicated that labor represents 40 to 50 percent of capital costs. Moreover, Babcock and Wilcox, which manufactures *and* installs scrubbers for both utilities and industrial boilers, specified that precise range and provided the most detailed information on scrubber costs.[7] Accordingly, this analysis reports labor costs associated with scrubber manufacturing and installation (and the associated employment impacts) as a range, based on the 40 to 50 percent range that we obtained from industry.

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[6] Roy Oommen, Eastern Research Group. "Methodology for Estimating Control Costs for the Industrial, Commercial, and Institutional Boilers and Process Heaters National Emission Standards for Hazardous Air Pollutants." Memorandum to Jim Eddinger, U.S. Environmental Protection Agency, OAQPS. October 2002.

[7] Personal communication with Phil Blazer, Babcock and Wilcox, January 5, 2010.

EXHIBIT 5. MODEL SCRUBBER COSTS AND DIRECT LABOR REQUIREMENTS

		MODEL SCRUBBER 1	MODEL SCRUBBER 2	MODEL SCRUBBER 3A	MODEL SCRUBBER 3B	MODEL SCRUBBER 4
	SIZE RANGE	980-9,800 MMBtu/hr	245 -980 MMBtu/hr	250-500 MMBtu/hr	250-500 MMBtu/hr	50-250 MMBtu/hr
COST ESTIMATES	CAPITAL COST (MILLION $)	$116	$56.7	$45.9	$13.5	$7.13
	LABOR COST - FABRICATION (MILLION $)	$15.5 - $19.3	$7.6 - $9.5	$6.1 - $7.7	$3.6 - $4.5	$1.9 - $2.4
	LABOR COST - INSTALLATION (MILLION $)	$30.9 - $38.7	$15.1 - $18.9	$12.2 - $15.3	$1.8 - $2.3	$1.0 - $1.2
	ANNUAL LABOR COST - O&M (MILLION $)	$9.7	$4.0	$3.1	$0.45	$0.19
DRECT LABOR ESTIMATES	FABRICATION LABOR (ANNUAL EQUIVALENT FTES)	128 - 160	63 - 78	51 - 63	30 - 37	16 - 20
	INSTALLATION LABOR (ANNUAL EQUIVALENT FTES)	510 - 638	249 - 312	202 - 252	30 - 37	16 - 20
	O&M AND ADMINISTRATIVE SUPPORT LABOR (FTE PER YEAR)	103	39	29	11	5

EXHIBIT 6. MANUFACTURING AND INSTALLATION LABOR AS A PERCENTAGE OF SCRUBBER CAPITAL COST

VENDOR	ESTIMATE OF DIRECT LABOR FOR MANUFACTURING AND INSTALLATION AS A PERCENT OF SCRUBBER INVESTMENT COSTS
Babcock and Wilcox	40 to 50 percent
Babcock Power	40 percent
Siemens (Wheelabrator, Inc.)	40 to 45 percent
Paramount Fabricators	25 percent
AE&E Von Roll	50 percent
Nol-Tec	50 percent
Hitachi	50 percent

Our analysis also divides labor costs between fabrication labor and installation labor. Based on input received from industry sources, we assume that fabrication (manufacturing) accounts for two-thirds of the labor costs reflected in the investment cost for each industrial boiler scrubber and that installation accounts for one-third.[8] For scrubbers constructed on electric utility boilers, these figures are reversed (i.e., installation represents two-thirds of labor costs and fabrication represents one-third) because more assembly occurs at the boiler site for these large scrubbers. Exhibit 5 summarizes our estimates of the labor costs associated with fabrication and installation for each model scrubber.

ESTIMATION OF MANUFACTURING AND INSTALLATION LABOR FOR EACH MODEL SCRUBBER

To translate the total direct labor costs associated with fabrication and installation of scrubbers into employment impacts, we estimate the allocation of labor costs among different types of laborers. Based on industry input, we estimate that mechanical and chemical engineers account for approximately 85 percent of the labor costs of fabrication, while structural iron and steel workers account for the remaining 15 percent.[9] We estimate that 100 percent of the labor costs of installation are attributable to work performed by boilermakers. To translate the costs associated with each kind of laborer to annual equivalent FTE, we use mean annual wage data from the Bureau of Labor Statistics (BLS), adjusted to account for total compensation (including total paid leave, insurance, and other benefits) using BLS data on average benefits for jobs in the manufacturing sector.[10] Exhibit 7 presents the estimates of annual wages and total

[8] Personal communication with Phil Blazer, Babcock and Wilcox, October 2009.

[9] Based on personal communication with Tony Licata, Babcock Power. November 29, 2009.

[10] Data on wages for chemical and mechanical engineers, structural iron and steel workers, and boilermakers came from BLS, National Compensation Survey: Occupational Earnings in the United States, 2008 (Table 4). Total compensation data are from BLS, Employer Costs for Employee Compensation-June 2009, September 10, 2009.

compensation that we used to estimate the direct employment impacts of scrubber fabrication and installation.

EXHIBIT 7. ANNUAL WAGES AND TOTAL COMPENSATION FOR LABOR RELATED TO SCRUBBER FABRICATION AND INSTALLATION

OCCUPATION	MEAN ANNUAL WAGE	TOTAL ANNUAL COMPENSATION
Mechanical and chemical engineers	$85,006	$128,350
Structural iron and steel workers	$59,224	$89,422
Boilermakers	$40,169	$60,651

Using the total annual compensation values listed in Exhibit 7, we estimated the number of annual equivalent FTEs that would be associated with the range of labor cost estimates presented in Exhibit 5. We estimate that the number of annual equivalent FTEs associated with scrubber fabrication ranges from 16 at small industrial scrubbers (assuming 40 percent of capital costs are labor) to 160 at large EGU scrubbers (assuming 50 percent of capital costs are labor). Similarly, we estimate that the number of annual equivalent FTEs associated with scrubber installation ranges from 16 at small industrial scrubbers (assuming 40 percent of capital costs are labor) to 638 at large EGU scrubbers (assuming 50 percent of capital costs are labor). Exhibit 8 presents the estimated labor requirements for manufacturing and installation by labor category.

EXHIBIT 8. MODEL SCRUBBER MANUFACTURING AND INSTALLATION LABOR REQUIREMENTS BY EMPLOYMENT CATEGORY

MODEL ID	MANUFACTURING LABOR FTEs		INSTALLATION LABOR FTEs
	ENGINEERS	IRON/STEEL WORKERS	BOILERMAKERS
1-Utility, large	103-129	25-31	510 - 638
2-Utility, small	50-63	12-15	249 - 312
3A-Industrial w/Utility costs	41-51	10-12	202 - 252
3B-Industrial, large	24-30	6-7	30 - 37
4-Industrial, small	13-16	3-4	16 - 20

DIRECT LABOR IMPACTS RELATED TO MODEL SCRUBBER OPERATION, MAINTENANCE, AND ADMINISTRATIVE SUPPORT

In addition to manufacturing and installation labor, we also estimate the number of annual full-time equivalents necessary for the operation, maintenance, and support of each model scrubber. Exhibit 9 summarizes the outputs generated by the CUECost Program and the

OAQPS cost manual algorithms that are relevant to these labor categories. Our approach for estimating the annual number of FTEs for each category is as follows:

- ***Operating Labor:*** We employ two different approaches to estimate the annual number of FTEs necessary for the operation of each model scrubber: one approach for electric utility scrubbers and a second for scrubbers at industrial boilers. For electric utility scrubbers, we rely on CUECost's estimates of the number of operators associated with each model scrubber. Because the cost algorithms in the OAQPS control cost manual do not estimate the number of operators for the industrial boiler model scrubbers, we use an alternative approach for these units. More specifically, we assume that the labor costs per scrubber operator used in CUECost ($62,400) for electric utility scrubbers apply to industrial boiler scrubbers as well. We then apply this value to the operating labor cost for industrial boilers, as presented in Exhibit 9.
- ***Administrative Support Labor:*** As indicated in Exhibit 7, CUECost and the OAQPS cost algorithms estimate the administrative labor costs associated with each model scrubber but not the annual number of administrative FTEs. To translate these costs into FTEs, we assume an annual labor cost of $49,600 based on data from BLS.[11]
- ***Maintenance Labor:*** Both CUECost and the OAQPS control cost algorithms generate maintenance cost outputs that do not distinguish between labor and materials cost. The CUECost documentation, however, indicates that the model estimates administrative labor based on the following equation:[12]

  (1) Admin. Labor = 0.3 (Operating Labor + Maintenance Labor)

  To estimate labor costs associated with maintenance, we solve Equation 1 for maintenance labor, using the administrative labor and operating labor cost estimates generated by CUECost and the OAQPS cost manual algorithms for each model scrubber as inputs. Although Equation 1 represents the approach employed by CUECost for estimating administrative labor costs for ***EGU*** scrubbers, we assume that the relationship reflected in Equation 1 applies to ***industrial boiler*** scrubbers as well. To convert annual maintenance labor costs to annual FTEs, we assume that the labor costs per scrubber operator used in CUECost ($62,400 per year) applies to scrubber maintenance workers as well.

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[11] Labor cost estimate for administrative workers derived from Bureau of Labor Statistics (BLS), "National Compensation Survey: Occupational Earnings in the United States, 2008," and BLS, "Employer Costs for Employee Compensation —June 2009," September 10, 2009.

[12] CUECost Program is available in R. Keeth, R. Blagg, C. Burklin, B. Kosmicki, D. Rhodes, and T. Waddell, *Coal Utility Environmental Cost (CUECost) Workbook User's Manual Version 1.0*, prepared for U.S. EPA, Table 3-2.

EXHIBIT 9. CUECOST AND OAQPS COST MANUAL OUTPUTS RELATED TO ANNUAL OPERATION, MAINTENANCE, AND SUPPORT LABOR

	MODEL SCRUBBER 1	MODEL SCRUBBER 2	MODEL SCRUBBER 3A	MODEL SCRUBBER 3B	MODEL SCRUBBER 4
Operator Labor (Annual FTEs)	37	9	6	Not estimated[1]	Not estimated[1]
Operating Labor Cost (million $)	$2.3	$0.59	$0.37	$0.45	$0.19
Maintenance Labor and Material Costs (million $)	$5.9	$2.9	$2.4	$0.17	$0.09
Administrative and Support Labor Cost (million $)	$1.4	$0.53	$0.40	$0.15[2]	$0.07[2]

Notes:
1. Impacts for Model Scrubbers 3B and 4 were estimated with the OAQPS control cost manual algorithms, which do not generate estimates of the operator labor (measured in annual FTEs) required for scrubber operations.
2. The OAQPS cost algorithms report these values as the cost of administrative support, without specifically indicating that these are labor costs. Because overhead is reported as a separate line item in the detailed results for Model Scrubbers 3B and 4, we assume that the cost of administrative support reported by the OAQPS cost manual algorithms reflects only the cost of administrative support labor.

Based on the approach outlined above, we generated estimates of the annual FTEs associated with the operation, maintenance, and administrative support for each model scrubber, as summarized in Exhibit 10.

EXHIBIT 10. DIRECT OPERATION, MAINTENANCE, AND SUPPORT LABOR (FTEs PER YEAR)

	MODEL SCRUBBER 1	MODEL SCRUBBER 2	MODEL SCRUBBER 3A	MODEL SCRUBBER 3B	MODEL SCRUBBER 4
Operator Labor	37	9	6	7	3
Maintenance Labor	38	19	15	1	1
Administrative Support Labor	28	11	8	3	1
Total	**103**	**39**	**29**	**11**	**5**

INDIRECT EMPLOYMENT IMPACTS

In this section, we present our analysis of the indirect employment impacts associated with scrubber manufacturing, installation, and operation. These indirect impacts include both upstream impacts and downstream impacts. Upstream impacts include the labor expended to produce the individual scrubber components purchased by scrubber manufacturers. According to the industry sources that we contacted, scrubber manufacturers typically rely on other vendors or sub-contractors to produce the individual components of a scrubber (e.g., the absorber vessel), while the scrubber manufacturers themselves design and assemble the various components. Indirect downstream impacts include labor expended (on an annual basis) by third-party vendors to support the operation of a scrubber.

Our analysis of indirect employment impacts mirrors our analysis of direct employment impacts in that we first use EPA's CUECost Program (for EGU scrubbers) and the cost algorithms included in the OAQPS control cost manual (for industrial boiler scrubbers) to obtain estimates of capital costs and operating costs for each model scrubber examined. To estimate upstream employment impacts, we use industry-specific employment/output ratios to estimate the labor associated with the production of each scrubber component, measured as annual equivalent FTEs. To estimate downstream employment impacts, we use BLS wage and benefits data to translate costs of O&M material inputs and waste disposal into annual FTE estimates. We discuss our analysis of these impacts in greater detail below.

ESTIMATION OF UPSTREAM INDIRECT LABOR FOR EACH MODEL SCRUBBER

The CUECost model and OAQPS cost algorithms that we use to estimate the total capital costs for each model scrubber also provide estimates of the costs associated with individual scrubber components. For EGU scrubbers, CUECost identifies these components as reagent feed systems, SO_2 removal systems, flue gas handling systems, waste/byproduct handling systems, and support equipment. For industrial scrubbers, the OAQPS control cost algorithms identify these components as pumps, mixing tanks, SO_2 removal systems, and ductwork. A portion of the capital costs reported for each of these items reflects labor expended by scrubber manufacturers for their design, assembly, and installation. As indicated above, the input that we received from industry suggests that the labor costs of scrubber producers may represent between 40 and 50 percent of the capital costs reported for a scrubber. Therefore, similar to our assessment of direct labor costs, we estimate the purchased equipment cost for each scrubber component as a range. The low end assumes that 50 percent of the reported scrubber equipment cost is labor (and the remaining 50 percent is the purchased equipment cost), and the high end assumes that 40 percent of the reported cost is labor (and the remaining 60 percent is the purchased equipment cost). Exhibit 11 presents the total equipment costs provided by the CUECost model and the OAQPS cost algorithms, as well as the range of purchased equipment costs that we used to estimate upstream labor impacts.

For each type of scrubber equipment, we assigned a specific industry or industries (as classified by NAICS codes), which we judged to be primarily responsible for the production of that input. As an example, we assume that the fabricated pipe and pipe fitting manufacturing industry is responsible for the production of flue gas handling systems. For each industry code assigned, we use employment and output data from the 2002 Economic Census Manufacturing Industry Series to determine the number of annual equivalent FTEs associated with a particular unit of production. By multiplying these unit values by the estimated purchase cost of each scrubber component, we developed estimates of the labor involved in producing each component. For scrubber components where we assigned multiple industries (e.g., waste/byproduct handling systems produced by both the cement manufacturing industry and the fabricated structural metal manufacturing industry), we developed a range of labor estimates. Based on the annual equivalent FTEs per unit of output for these industries and the estimated purchased cost of equipment, we developed the upstream labor estimates presented in Exhibit 11.

EXHIBIT 11. MODEL SCRUBBER COSTS AND INDIRECT LABOR REQUIREMENTS

			MODEL SCRUBBER 1	MODEL SCRUBBER 2	MODEL SCRUBBER 3A	MODEL SCRUBBER 3B	MODEL SCRUBBER 4
	SIZE RANGE		980-9,800 MMBtu/hr	245 -980 MMBtu/hr	250-500 MMBtu/hr	250-500 MMBtu/hr	50-250 MMBtu/hr
COST ESTIMATES	TOTAL EQUIPMENT COSTS (MILLION $)		$82.5	$40.5	$32.8	$6.8	$3.4
	PURCHASED COST OF EQUPMENT (MILLION $)		$41.3 - $49.5	$20.2 – $24.3	$16.4 – $19.7	$3.4 - $4.1	$1.7 - $2.1
	O&M INPUT AND DISPOSAL COSTS (MILLION $)		n/a	n/a	n/a	$0.62	$0.17
INDIRECT LABOR ESTIMATES	UPSTREAM LABOR (ANNUAL EQUIV. FTE)[1]	LOW	174-203	82-103	67-84	15-17	7-9
		HIGH	210-243	97-124	80-101	18-19	9-11
	DOWNSTREAM LABOR (FTES PER YEAR)		n/a	n/a	n/a	4	1

Notes:

1. The low values for upstream labor assume that 50 percent of the reported scrubber equipment cost is labor (and the remaining 50 percent is the purchased equipment cost), and the high end assumes that 40 percent of the reported cost is labor (and the remaining 60 percent is the purchased equipment cost).

ESTIMATION OF DOWNSTREAM INDIRECT LABOR FOR EACH MODEL SCRUBBER

In addition to the labor required to produce individual scrubber components, we also estimate the annual labor expended by vendors who provide support services for the routine operation of scrubbers. As described above, industrial boiler scrubbers typically rely on external vendor support for waste handing and disposal systems, reagent handling systems, and limestone grinding systems, whereas electric utilities perform these functions onsite. Our assessment of downstream labor associated with these activities is therefore limited to scrubbers installed at industrial boilers.Output from the OAQPS cost algorithms include the annual cost of chemical inputs—lime and dibenzylideneacetone (dba)—as well as the annual cost of gypsum disposal, as presented in Exhibit 11. Information provided by industry sources suggests that labor costs represent approximately 30 percent of the costs associated with lime and 45 percent of the costs associated with dba and gypsum disposal.[13] Based on this information and the estimated costs for each of these items, we estimated the total annual costs of labor associated with these downstream activities. To translate these labor costs to annual FTEs, we obtained wage and total compensation data for chemical workers (used for lime and dba) and refuse collectors (applied to gypsum disposal) from the Bureau of Labor Statistics (BLS), as summarized in Exhibit 12. Exhibit 11 presents our estimates of downstream labor for each model scrubber.

EXHIBIT 12. ANNUAL WAGES AND TOTAL COMPENSATION FOR LABOR RELATED TO CHEMICAL O&M INPUTS AND WASTE DISPOSAL

OCCUPATION	MEAN ANNUAL WAGE	TOTAL ANNUAL COMPENSATION
Chemical processing machine setters, operators, and tenders	$44,285	$66,866
Refuse and recyclable material collectors	$26,888	$40,598
Source: Estimates derived from Bureau of Labor Statistics (BLS), “National Compensation Survey: Occupational Earnings in the United States, 2008,” and BLS, “Employer Costs for Employee Compensation —June 2009,” September 10, 2009.		

SUMMARY AND DISCUSSION OF RESULTS

Exhibit 13 summarizes the results of our analysis. As indicated in the exhibit, the estimated employment impacts for EGU scrubbers are much greater than those for industrial boiler scrubbers. This reflects the large size of EGU scrubbers relative to scrubbers fitted to industrial boilers. The results in Exhibit 13 also show that the direct employment impacts associated with scrubber installation exceed the direct manufacturing impacts for EGU scrubbers, whereas the two are roughly the same for industrial boiler scrubbers. The difference in the distribution of direct labor impacts for EGU scrubbers versus industrial boiler scrubbers is consistent with the input we received

[13] Personal communication with Bob Roden, Carmeuse Lime & Stone; Mike Schantz, Chemical Lime; and Lance Steron, Headwaters. October 2009

from industry representatives indicating that larger utility scrubbers are typically shipped as components and assembled at the plant. In contrast, industrial boiler scrubbers are more frequently shipped as whole units or as fewer components.

As indicated above, we examined the employment impacts for Model Scrubber 3 using both EPA CUECost Program (reported as Model Scrubber 3A) and the OAQPS control cost manual cost algorithms (reported as Model Scrubber 3B). The former assumes that a boiler installs extensive scrubber support systems onsite, whereas the latter assumes that the unit contracts with off-site vendors for this support. The results in Exhibit 13 suggest that the one-time employment impacts for Model Scrubber 3 depend significantly on facilities' decisions with respect to these support systems; these impacts are greater under the 3A assumptions than 3B by more than a factor of four. We suspect that the difference reflects not just the presence or absence of scrubber support equipment but also differences in the methodology employed by CUECost and the OAQPS cost manual algorithms. For example, CUECost may assume that each scrubber is highly customized, whereas the OAQPS cost algorithms may assume that industrial boiler scrubbers are more standardized. Identifying the key differences would require a detailed review of CUECost and the OAQPS control cost manual, which is outside the scope of this document.

The values presented in Exhibit 13 do not account for the portion of the U.S. scrubber market that is supplied by foreign manufacturers. However, we believe that effect of this omission on our results is negligible. Communications with industry sources suggest that virtually all manufacture of FGD scrubbers installed in the U.S. occurs domestically, due to the prohibitive cost of shipping such large pieces of equipment.[14] In addition, nearly all materials used in scrubber manufacture are produced domestically as well, with few exceptions.[15] However, one industry source did predict that off-shore fabrication of scrubbers may become viable in the future if demand emerges for smaller (i.e., shop-assembled) scrubbers for industrial applications.[16]

The employment estimated in this document also do not account for induced employment effects. Laborers employed for scrubber fabrication, installation, and operational activities would spend their wages on goods and services, leading to additional employment impacts among the providers of these goods and services (and their suppliers).

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[14] Personal communication with David Foerter, Institute of Clean Air Companies, December 10, 2009.

[15] Personal communication with Phil Blazer, Babcock and Wilcox, January 5 2010. For wet scrubbers, agitators and parts of the ball mill are purchased abroad; for dry scrubbers, atomizers are purchased abroad.

[16] Ibid, January 10, 2010.

EXHIBIT 13. SUMMARY OF DIRECT AND INDIRECT EMPLOYMENT IMPACTS, BY MODEL SCRUBBER

		MODEL SCRUBBER 1	MODEL SCRUBBER 2	MODEL SCRUBBER 3A	MODEL SCRUBBER 3B	MODEL SCRUBBER 4
MODEL SCRUBBER DESCRIPTION		• EGU Scrubber • Capacity: 980 – 9,800 MMBtu/hr	• EGU Scrubber • Capacity: 245 -980 MMBtu/hr	• Industrial Boiler Scrubber • Capacity: 250-500 MMBtu/hr • Analyzed with CUECost	• Industrial Boiler Scrubber • Capacity: 250-500 MMBtu/hr • Analyzed with OAQPS cost manual algorithms	• Industrial Boilers Scrubber • Capacity: 50-250 MMBtu/hr
DIRECT EMPLOYMENT IMPACTS	Manufacturing Labor (Annual Equiv. FTE)	128 - 160	63 - 78	51 – 63	30 – 37	16 – 20
	Installation Labor (Annual Equiv. FTE)	510 - 638	249 – 312	202 – 252	30 – 37	16 - 20
	Operation, Maintenance, and Administrative Support Labor (Annual FTEs)	103	39	29	11	5
INDIRECT EMPLOYMENT IMPACTS	Upstream Manufacturing Labor (Annual Equiv. FTE)	174 – 243	82 – 124	67 – 101	15 – 19	7 – 11
	Downstream Vendor Labor (Annual FTEs)	n/a	n/a	n/a	4	1
Total One-Time Employment Impacts per Model Scrubber (Annual Equiv. FTE)[1]		848 – 1,001	409 – 493	333 – 400	77 – 91	40 - 48
Annual Recurring Employment Requirements per Model Scrubber (FTEs) per year)[2]		103	39	29	16	6

Notes:

1. Total one-time employment impacts do not reflect the sum of the range of direct and indirect one-time employment impacts because of how we estimated a range of impacts based on the percentage of capital costs that are attributable to labor. Taking Model Scrubber 1 as an example, when we assume that labor costs are 40 percent of total capital costs, we estimate direct employment impacts to total 638 FTEs and indirect employment impacts—which are related to the 60 percent of capital costs that are *not* attributable to direct labor—to be between 210 and 243 FTEs, for a total of 848 – 881 FTEs. Likewise, under the 50-percent-labor scenario, we estimate direct employment impacts to be 798 FTEs and indirect employment impacts to be between 174 and 203 FTEs, for a total of 972 – 1,001 FTEs. Accordingly, the full range of one-time employment impacts for Model Scrubber 1 is 848 - 1,001 FTEs.
2. Recurring employment impacts include labor required for the operation, maintenance, and administrative support for each scrubber.

With respect to the application of these employment impact estimates in a policy setting, we recommend the following:

- ***Distinguish between one-time and recurring labor requirements:*** The production and installation of a scrubber represents a one-time occurrence, whereas the operation and maintenance of a scrubber are ongoing activities. Because of this temporal inconsistency, one-time employment impacts should be reported separately from annual impacts. The two are additive in that they represent distinct components of the employment effect, but they cannot be added together because they are measured in different units.
- ***Net employment impacts:*** While air pollution regulations may create jobs related to the manufacture, installation, and operation of scrubbers, the resources expended on scrubbers may divert resources from other uses, potentially reducing the number of jobs in other parts of the economy. Under these circumstances, the *net* employment impact associated with scrubbers would be less than the estimates presented in Exhibit 13. The magnitude of this effect, however, is uncertain and depends on a number of factors, including the extent to which resources expended on scrubbers would have otherwise been used by affected companies for production activities domestically or overseas. Related to this issue, scrubbers may replace existing emissions controls at facilities affected by a new rulemaking. In such cases, the *recurring* employment impacts associated with scrubbers should be estimated net of the *recurring* employment effects associated with the existing control technology.
- ***Recognition of uncertainty:*** We recommend that EPA note the uncertainties surrounding our results when using them in the context of a regulatory impact analysis. These uncertainties include:
    - Lack of clarity on the share of scrubber capital costs that reflects labor costs associated with scrubber manufacturing and installation.
    - The use of a model scrubber approach. Actual employment impacts for individual scrubbers may deviate from these estimates due to site-specific characteristics and other factors not accounted for in our analysis.
    - Incomplete estimates for indirect employment impacts. The indirect employment estimates presented in this document are not comprehensive because they only reflect one step in the production/value chain (i.e., firms that provide parts and materials to scrubber manufacturers). Therefore, we may underestimate the full indirect employment impacts associated with scrubber production. For example, our estimates do not include workers in steel mills producing metal sheets for scrubber components or laborers in the iron mines that supply steel mills.

APPENDIX

The analysis presented in the main body of this memo estimates the average employment impacts associated with the manufacture, installation, and operation of flue gas desulfurization (FGD) scrubbers. This appendix describes our efforts to assess the reasonableness of these estimates by consulting the following sources:

1) Published estimates of the number of one-time and permanent jobs associated with the installation of scrubbers at large utility boilers;
2) Input provided by industry experts on the estimates in the main body of this memorandum; and
3) Other data sources with information related to key inputs used in our analysis.

Through this process, we obtained information on the labor impacts associated with the installation, operation, and maintenance of FGD scrubbers at electric utility boilers of various sizes. We were not able to obtain validating information for industrial boilers. Based on our communications with industry experts, employment data for industrial boiler scrubbers are difficult to obtain given that these units generally install shop-fabricated scrubbers, rather than the field-fabricated scrubbers commonly installed at electric utility boilers.[17] We also did not find information that would allow us to validate our estimates of the direct employment impacts of ongoing administrative support for scrubber operation and maintenance, or for upstream or downstream indirect employment impacts. Accordingly, this appendix focuses on the manufacture and installation labor, operator labor, and maintenance labor estimates for utility boilers (Model Scrubbers 1 and 2). These values are highlighted in grey in Exhibit A-1.

Overall, our findings are as follows:

- ***One-time employment impacts:*** We found that our estimates of the direct employment impacts of scrubber manufacture and installation at medium/large utilities were on the high end of the range of reported values from recent scrubber installations, though still generally consistent with the observations of industry experts.
- ***Ongoing employment impacts:*** Numerous sources suggested that our estimates of the employment impacts of scrubber operations and maintenance at medium/large and small utilities may overstate these impacts, exceeding actual employment impacts by factors ranging from two to four.

[17] Personal communication with Robert Hilton, Alstom Power. March 31, 2011.

EXHIBIT A-1. IEc ESTIMATES OF DIRECT EMPLOYMENT IMPACTS FOR SCRUBBERS INSTALLED AT ELECTRIC UTILITY BOILERS

	MEDIUM/LARGE UTILITY BOILERS (MODEL SCRUBBER 1)	SMALL UTILITY BOILERS (MODEL SCRUBBER 2)
SIZE RANGE	100-1000 MW	25-100 MW
TYPICAL SIZE (USED IN CUECOST MODELING)	750 MW	100 MW
MANUFACTURING LABOR (ANNUAL EQUIVALENT FTEs)	128 – 160	63 – 78
INSTALLATION LABOR (ANNUAL EQUIVALENT FTEs)	510 – 638	249 – 312
OPERATOR LABOR (FTE PER YEAR)	37	9
MAINTENANCE LABOR (FTE PER YEAR)	38	19
ADMINISTRATIVE SUPPORT LABOR (FTE PER YEAR)	28	11
Source: Compiled from main body of memorandum.		

PUBLISHED ESTIMATES

As a first step in assessing the reasonableness of the employment impacts developed in the main body of this memorandum, we obtained published estimates of the actual number of jobs created by installations of scrubbers at medium and large utilities. Chad Whiteman, formerly at the Institute of Clean Air Companies, served as our primary source of such estimates. Between 2005 and 2009, Mr. Whiteman collected published estimates of both the maximum number of construction jobs on site during scrubber installation and the number of permanent jobs created at utilities for operation and maintenance of scrubbers.[18] We also obtained information on the employment impacts of a scrubber installed at a coal-fired plant in New Hampshire from Dr. Lisa Shapiro at Gallagher, Callahan and Gartrell, P.C. In 2009, Dr. Shapiro prepared a report estimating the total economic impacts of the planned construction of a wet FGD scrubber at Merrimack Station in Bow, New Hampshire.[19] Construction of the scrubber began in 2009, and Dr. Shapiro has since confirmed the 2009 report's estimates of the direct employment impacts of the scrubber's installation with observed data.[20] Finally, we obtained additional information on the employment impacts of scrubber installations at other large utility boilers from press releases and other publicly available documents. From these sources, we obtained 14 estimates of the number of jobs required for the

[18] Personal communication with Chad Whiteman, formerly of the Institute of Clean Air Companies. March 31, 2011.

[19] Shapiro, Lisa. "The Economic Impacts of Constructing a Scrubber at Merrimack Station." Prepared for Public Service Company of New Hampshire, March 13, 2009. Available at http://www.gcglaw.com/resources/economic/pdfs/scrubber.pdf.

[20] Personal communication with Lisa Shapiro, Gallagher, Callahan and Gartrell, P.C. March 28, 2011.

installation of scrubbers at medium and large utility boilers, and ten estimates of the jobs created for ongoing operation and maintenance of FGD scrubbers. These estimates are presented in Exhibits A-2 and A-3. Based on the descriptions of the jobs involved at each scrubber installation, we assume that these estimates do not include the employment impacts of manufacturing the scrubber units. Note that none of the sources described above provided information on the employment impacts of installing scrubbers at small utility boilers (e.g., smaller than 100 MW).

EXHIBIT A-2. PROJECT EMPLOYMENT DATA FOR INSTALLATION OF FGD SCRUBBERS AT MEDIUM AND LARGE CAPACITY ELECTRIC UTILITY BOILERS

COMPANY	POWER PLANT	CAPACITY (MW)	MAXIMUM NUMBER OF JOBS ON SITE[1]	SOURCE
Minnesota Power	Taconite Harbor Energy Center	225	450	1
Alabama Electric Cooperative	Charles R. Lowman Power Plant, Unit 1	258	600	1
Sunbury Generation	Sunbury Generation	425	300	1
Public Service of NH	Merrimack Power Station	460	300-500[2]	2
Reliant Energy	Cheswick Generating Station	580	300	1
Constellation Energy	Brandon Shores Power Plant	643	300	1
American Electric Power	Connesville Generating Station, unit 4	780	500	1
Tennessee Valley Authority	Bull Run	881	245	1
Tennessee Valley Authority	Paradise Fossil Power Plant, Unit 3	977	300	1
Ameren	Sioux Power Plant	986	600	3
Allegeny Energy	Fort Martin Power Plant	1,107	350	1
Reliant Energy	Keystone Power Plant	1,700	800	1
Allegheny Energy	Hatfield Ferry	1,710	350[3]	4
Duke Energy	Belews Creek Power Plant	2,240	950	5

Sources:

1. Information collected from publicly available sources by Chad Whiteman, formerly at the Institute for Clean Air Companies.
2. Information obtained from the Public Service of New Hampshire by Lisa Shapiro, Gallagher, Callahan and Gartrell, P.C.
3. "Ameren's $600M Sioux Plant scrubbers open." St. Louis Business Journal. November 4, 2010. Available at http://www.bizjournals.com/stlouis/news/2010/11/04/amerens-600m-sioux-plant-scrubbers.html.
4. "Hatfield's Ferry Power Station Scrubber Project." Available at http://www.alleghenyenergy.com/Newsroom/Scrubber.Hat.2page.pdf.
5. "Duke emission-scrubbers running at Belews Creek." Winston-Salem Journal. June 3, 2008. Available at http://www2.journalnow.com/news/2008/jun/03/duke-emission-scrubbers-running-at-belews-creek-ar-381454.

Notes:

1. Except where otherwise noted, estimates of on-site jobs created are based on observation of actual scrubber construction.
2. 300 workers were observed on site. An additional 200 off-site workers (including designers and delivery personnel) were estimated based on a review of the project's contracts.
3. Number of jobs projected before construction began.

As Exhibit A-2 shows, at the 14 scrubber installations for which we collected data, the direct employment impacts of installation ranged from 245 to 950 FTEs, with an average of 464 FTEs. In the main body text, scrubbers installed at medium and large utility boilers are represented with a model scrubber installation covering a size range of 100-1,000 MW. For the ten utility boilers in the exhibit with capacities between 100 and 1,000 MW, the average number of on-site jobs required for scrubber installation is 405. By comparison, our estimate of 510-638 annual equivalent FTEs for a model scrubber installed at a 750-MW boiler is on the high side of the observed range, exceeding the average by between 105 and 233 FTEs.

As shown in Exhibit A-3, the number of jobs created for the operation and maintenance of installed scrubbers at the ten utility boilers examined ranged from 15 to 55 FTE per year, with an average of 28.5 FTEs. At the seven boilers with capacities between 100 and 1,000 MW (i.e., with capacity consistent with the Model Unit analyzed in the analysis in the main body text), the average number of O&M jobs created was 25.7 FTEs. Our estimate of 75 FTEs created for the O&M of scrubbers installed at medium to large utility boilers falls outside the range presented in Exhibit A-3 and exceeds the average number of O&M jobs at comparable boilers by a factor of nearly three.

INDUSTRY EXPERTS

In addition to obtaining observational data on the actual number of jobs created for the installation, operation, and maintenance of scrubbers at utility boilers, we also solicited input from industry experts. We contacted representatives of scrubber manufacturers, industry associations, and utility companies, though most were unable to comment on our estimates. The information that we present in this section draws from two representatives of Alstom Power:[21]

- **James Yann**, Managing Director for North American Environmental Control Systems
- **Robert Hilton**, Vice President of Power Technologies for Government Affairs

In testimony delivered to the U.S. Senate Committee on Environment and Public Works during a joint hearing entitled "Clean Air Act and Jobs," Mr. Yann noted that a wet flue gas desulfurization installation on a 500-600 MW unit will provide "the equivalent of about 775 full time jobs… not including jobs provided for all the equipment suppliers and delivery services involved in delivering materials and equipment to the site."[22] Assuming that this estimate includes labor for both manufacture and installation of scrubbers, this number falls within the range of 638 to 798 annual equivalent FTEs reported in the main body text.

[21] Alstom Power supports the power generation industry through the design, manufacture, servicing, and supply of products and systems. According to Mr. Yann's recent Senate testimony, Alstom Power is the world's largest air pollution control company.

[22] Testimony of James Yann, Managing Director for North American Environmental Control Systems, before the U.S. Senate Committee on Environment and Public Works, Subcommittees on Clean Air and Jobs. March 17, 2011.

EXHIBIT A-3. ESTIMATES OF JOBS REQUIRED FOR OPERATION AND MAINTENANCE OF FGD SCRUBBERS AT INDIVIDUAL MEDIUM AND LARGE ELECTRIC UTILITY BOILERS

COMPANY	POWER PLANT	CAPACITY (MW)	NEW JOBS FOR SCRUBBER O&M[1]	SOURCE
Sunbury Generation	Sunbury Generation	425	15	1
Reliant Energy	Cheswick Generating Station	580	20[2]	2
Constellation Energy	Brandon Shores Power Plant	643	20	1
Duke Energy	Marshall Steam Station	670	25	1
American Electric Power	Connesville Generating Station, unit 4	780	40	1
Tennessee Valley Authority	Paradise Fossil Power Plant, Unit 3	977	40	1
Ameren	Sioux Power Plant	986	20	3
PPL	Mountour	1,625[3]	30	1
American Electric Power	Kammer-Mitchell	1,632[4]	55	1
Reliant Energy	Keystone Power Plant	1700	20	1

Sources:

1. Information collected from publicly available sources by Chad Whiteman, formerly at the Institute for Clean Air Companies.
2. "Springdale Power Plant To Get $250M Scrubber." Pittsburgh Tribune-Review. July 6, 2006. Available at http://www.pittsburghlive.com/x/pittsburghtrib/news/s_460793.html.
3. "Ameren's $600M Sioux Plant Scrubbers Open." St. Louis Business Journal. November 4, 2010. Available at http://www.bizjournals.com/stlouis/news/2010/11/04/amerens-600m-sioux-plant-scrubbers.html.

Notes:

1. Except where otherwise noted, estimates of new jobs created for operation and maintenance of scrubbers are based on observation of actual scrubbers in operation.
2. Number of jobs projected before scrubber was installed.
3. Combined capacity for two units at the Montour plant that operated FGDs in 2009, according to DOE's Form EIA-923 Database.
4. Combined capacity for two units at the Mitchell plant that operated FGDs in 2009, according to DOE's Form EIA-923 Database.

Communication with Mr. Hilton confirmed that our overall estimate of the direct employment impacts of manufacturing and installing scrubbers at medium and large utilities was in line with Mr. Yann's testimony.[23] Mr. Hilton also commented on other values that we used in our memorandum to estimate direct employment impacts of scrubber fabrication and installation, noting that our estimates of scrubber capital costs for a 750-MW utility boiler were lower than he would expect, as were our estimates of

[23] Personal communication with Robert Hilton, Vice President of Power Technologies for Government Affairs, Alstom Power. March 30, 2011.

the total annual compensation of boilermakers and of mechanical and chemical engineers. If these values are indeed too low, it is possible that they would have offsetting effects on our estimate of the total direct employment impacts of scrubber manufacture and installation. Increasing capital costs would increase the direct labor costs for scrubber manufacture and installation (assuming that the percent of capital costs attributable to labor remains constant), thereby increasing direct employment impacts. However, increasing total annual compensation for engineers and boilermakers would reduce the number of annual equivalent FTEs associated with a particular direct labor cost.

Exhibit A-4 shows how the estimate of the employment impacts of scrubber installation changes when the total annual compensation for boilermakers increases from $60,000 (the value used in the main body text, based on mean annual wage data from the Bureau of Labor Statistics) to $100,000 (the value suggested by Mr. Hilton, based on review of wages posted by the Boilermakers Local 169).[24] As the exhibit shows, increasing total annual compensation for boilermakers by $40,000 decreases employment impacts for medium/large utility boilers by 201-251 FTEs and for small utility boilers by 98-123 FTEs. The illustrative analysis in Exhibit A-4, however, leaves the average capital cost of a scrubber unchanged relative to the values used in the main body text, as Mr. Hilton did not provide an alternative estimate for this cost.

EXHIBIT A-4. COMPARISON OF EMPLOYMENT IMPACTS OF SCRUBBER INSTALLATION, USING TOTAL ANNUAL COMPENSATION FOR BOILERMAKERS OF $60,000 AND $100,000.

	MEDIUM/LARGE UTILITY BOILERS (MODEL SCRUBBER 1)	SMALL UTILITY BOILERS (MODEL SCRUBBER 2)
INSTALLATION LABOR ASSUMING $60,000 TOTAL ANNUAL COMPENSATION FOR BOILERMAKERS (ANNUAL FTEs)	510 – 638	249 - 312
INSTALLATION LABOR ASSUMING $100,000 TOTAL ANNUAL COMPENSATION FOR BOILERMAKERS (ANNUAL FTEs)	309 – 387	151 - 189

Mr. Hilton also noted that our estimates of the operating, maintenance, and administrative and support labor impacts of FGD scrubbers significantly overestimated the true labor requirements of such systems. Mr. Yann's testimony also noted that labor requirements for operation and maintenance of scrubbers at large utility boilers can range from 10 to 30 FTEs, much less than the 75 FTEs estimated in the main text. Mr. Hilton recognized that

[24] Email communication with Robert Hilton, Vice President of Power Technologies for Government Affairs, Alstom Power. March 30, 2011. Boilermaker wages are posted at http://www.boilermakerslocal169.com/PDF%20FILES/LOCAL%20AREA%20WAGES%2001%2001%202011.pdf.

models such as the CUECost Program used in our analysis assume that operating and maintenance costs are a flat percentage of total capital costs, but noted that in his experience, scrubber operation is largely automated, with a typical FGD unit requiring no more than eight operators. Furthermore, he noted that utilities usually use the general maintenance pool for the entire plant to perform maintenance on scrubber systems, making it difficult to determine the extent to which scrubbers actually require additional maintenance personnel.[25] Mr. Hilton supported his estimates by contacting two large utilities with wet scrubber systems, one with 12 total personnel (including a supervisor, operators, maintenance personnel, a computer tech, and a chemist), and the other with 16 (excluding maintenance, which comes out of the plant's overall maintenance pool).[26]

OTHER DATA SOURCES

We consulted two additional sources to assess the reasonableness of our O&M labor estimates for scrubbers at small, medium, and large utility boilers. Using formulas from the Integrated Planning Model (IPM), we first checked to see if the operating labor cost estimates generated by the CUECost program were consistent with other models used by EPA.[27] For model scrubbers at 750-MW and 100-MW utility boilers, the IPM formulas for operating labor costs produced estimates identical to those generated by CUECost, suggesting that CUECost simply uses the IPM formulae or *vice-versa*.

We also reviewed the U.S. Energy Information Administration's Form EIA-923 database, which collects information on power plant generation and fuel consumption, as well as data on flue gas particulate (FGP) and FGD control operations. We selected 367 utility boilers from the database (1) that operated scrubbers in 2009 and (2) for which we could conclusively identify the capacity of the generating unit associated with the scrubber. Of these 367 boilers, 137 had capacities less than 100 MW, corresponding to the small utility boilers in our analysis, and the remaining 230 had capacities between 100 MW and 1,000 MW, corresponding to the medium/large utility boilers in the analysis. On average, the selected boilers with capacities between 100 MW and 1,000 MW spent about $980,000 on operating labor for scrubbers in 2009, while the selected boilers with capacities less than 100 MW spent an average of $154,000. These numbers are substantially lower than the CUECost program's estimates of $2,310,000 and $590,000 for medium/large utility boilers and small utility boilers, respectively. Exhibit A-5 shows how our estimates of operating labor requirements decrease when the average operating labor costs for each boiler type from the Form EIA-923 data are used in place of the CUECost estimates. The revised estimate of 16 FTEs for operation of scrubbers at medium/large utilities is consistent with the values supplied by industry experts. If we adjust maintenance and administrative support labor (the other two categories of permanent employment) in

[25] *Ibid*.

[26] Email communication with Robert Hilton, Vice President of Power Technologies for Government Affairs, Alstom Power. March 30, 2011.

[27] IPM formulas were obtained from Documentation Summary for EPA Base Case 2004 Using IPM (V.2.1.9) (2004 Update). Appendix 5.1: SO_2 Scrubber Engineering Cost Equations. Available at http://www.epa.gov/airmarkets/progsregs/epa-ipm/docs/bc5emission.pdf.

proportion to the decrease in operating labor, our estimates of total recurring annual employment impacts would decrease from 103 and 39 FTEs per year for medium/large and small utility boilers, respectively, to 44 and 10 FTEs.

EXHIBIT A-5. OPERATING LABOR REQUIREMENTS FOR SCRUBBERS AT SMALL AND MEDIUM/LARGE UTILITY BOILERS USING LABOR COST ESTIMATES DERIVED FROM CUECOST AND LABOR COST DATA OBTAINED FROM THE FORM EIA-923 DATABASE

		MEDIUM/LARGE UTILITY BOILERS (MODEL SCRUBBER 1)	SMALL UTILITY BOILERS (MODEL SCRUBBER 2)
ORIGINAL ESTIMATES BASED ON CUECOST OUTPUTS	OPERATING LABOR COST (THOUSAND $)	$2,310	$590
	OPERATING LABOR (ANNUAL FTES)	37	9
REVISED ESTIMATES USING FORM EIA-923 AVERAGE OPERATING LABOR COSTS	OPERATING LABOR COST (THOUSAND $)	$980	$153
	OPERATING LABOR (ANNUAL FTES)	16	5

CONCLUSION

The information presented in this appendix suggests that our employment impacts estimates for scrubber manufacturing and installation are fairly consistent with other estimates. While near the high end of the range, our estimates of employment impacts for scrubber installation (excluding manufacture) are within the range of values reported for specific scrubber installation projects at medium/large utility boilers. In addition, our overall estimates of employment impacts of scrubber installation *and* manufacturing at medium/large utility boilers are consistent with testimony recently delivered by an industry expert before the U.S. Senate Committee on Environment and Public Works.

While the available data suggest that our employment impact estimates for scrubber manufacturing and installation are reasonable, the sources that we consulted indicate that we may overestimate the labor required to operate and maintain scrubbers at medium/large capacity electric utility boilers. This may reflect the overestimation of scrubber operating and maintenance costs in EPA's CUECost model.