Attachment A

Exponent®

Public Comments on MSHA's Proposed Rule: Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors

RIN 1219-AB64

Specific Comments on: Preliminary Regulatory Economic Analysis

AB64-COMM-92-1

Exponent

Public Comments on MSHA's Proposed Rule:

Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors

RIN 1219-AB64

Specific Comments on: Preliminary Regulatory Economic Analysis

Prepared for

Murray Energy Corporation
29325 Chagrin Boulevard, Suite 300
Pepper Pike, OH 44122

Prepared by

Robin C. Cantor, Ph.D.
Exponent
1800 Diagonal Road, Suite 500
Alexandria, VA 22314

April 27, 2011

Doc. no. 1007321.000 E0T0 0411 RAC1

Contents

List of Figures

List of Tables

Qualifications of Author

Dr. Cantor is a Principal in the Alexandria, Virginia, office of Exponent. She specializes in applied economics, environmental and energy economics, statistics, and risk management. She has a B.S. in mathematics from Indiana University of Pennsylvania with a specialization in statistics, and a Ph.D. in economics from Duke University with a specialization in econometrics.

Dr. Cantor has more than 25 years of research, teaching, and consulting expertise, including several areas of applied economics, environmental and energy economics, statistical modeling, risk management, and liability claims analysis. Her testimonial experience includes commercial damage analysis, statistical and economic analysis of health-care billed charges, economic analysis of class certification issues, product liability estimation in bankruptcy matters, product liability analysis for insurance disputes, statistical analysis of asbestos settlements, analysis of premises and product claims, cost contribution allocation in Superfund disputes, analysis of derailment risks, and reliability of statistical models and estimation methods.

Dr. Cantor has been qualified in state and federal court as an expert on economics, including microeconomics, econometrics, cost/benefit analysis, cost/benefit methodologies, risk management, and asbestos claims analysis. She has submitted analysis, testimony, and affidavits in federal arbitration, regulatory and Congressional proceedings, and federal and state courts.

Dr. Cantor was the 2002 President of the Society for Risk Analysis. In 2001, she was appointed as a member of the Research Strategies Advisory Committee of the U.S. Environmental Protection Agency's Science Advisory Board. She is a past President of the Board of Directors for MATRIX, The Business Center for Women and Minorities. She is a member of the Society for Risk Analysis, the American Economic Association, and the Women's Council on Energy and the Environment. Dr. Cantor serves or has served on science review and advisory panels for the National Academies of Science, the National Science Foundation, the Johns Hopkins University Graduate Part-Time Program in Environmental Engineering and Science, the National Center for Environmental Decision-making Research, the Carnegie Council on Ethics and International Affairs, the National Oceanic and Atmospheric Administration, the National Academy of Public Administration, and the Consortium for International Earth Science Information Network. She has served on the editorial boards of the *Journal of Risk Analysis* and the *Journal of Risk Research.* Dr. Cantor has a faculty appointment in the Graduate Part-time Program in Environmental Engineering, Science and Management of the Johns Hopkins University.

Dr. Cantor has published scholarly articles on numerous areas of economic analysis. Her publications include refereed journal articles, book chapters, expert reports, reports for federal sponsors, a co-authored book on economic exchange under alternative institutional and resource conditions, and an edited volume on product liability.

Exponent has been engaged by Murray Energy Corporation ("MEC") to conduct a review of the health, exposure, and economic data and methods used for risk assessment in the proposed rule. In particular, Dr. Cantor was asked to independently review the Preliminary Regulatory Economic Analysis (PREA)[1] prepared by MSHA, to evaluate the economic analysis of costs and benefits of the proposed rules contained therein in the context of standard methods for regulatory analysis, and to offer comments based on her evaluation.

A preliminary version of Dr. Cantor's comments was presented to the Mining Safety and Health Administration ("MSHA") panel at the February 15, 2011, public hearing in Arlington, Virginia, concerning the Proposed Rule on Lowering Miners' Exposure to Respirable Coal Mine Dust Including Continuous Personal Dust Monitors ("the proposed rule").[2] Dr. Cantor's earlier comments, with further elaboration and in some cases, additional analysis for MSHA's consideration, are incorporated by reference in these final comments.

---

1 *See* U.S. Department of Labor, Mine Safety and Health Administration, Office of Standards, Regulations, and Variances, "Preliminary Regulatory Economic Analysis For Lowering Miners' Exposure to Respirable Coal Mine Dust Including Continuous Personal Dust Monitors Proposed Rule," Document Number RIN 1219-AB64 (Sep. 2010) (the "PREA").

2 *See* Federal Register, "Department of Labor, Mine Safety and Health Administration, 30 CFR Parts 70, 71, 72, et al., Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors; Proposed Rule" *available at* http://www.msha.gov/REGS/FEDREG/PROPOSED/2010Prop/2010-25249.pdf (last visited Apr. 14, 2011) (the "Proposed Rule").

A copy of Dr. Cantor's current *curriculum vitae* is included as Attachment A. Other Exponent staff members have also worked at her direction on this matter.

Executive Summary

As a federal agency charged with the protection of miners' health and safety, MSHA is responsible for promulgating and enforcing rules to improve mining conditions and reduce the occupational health effects of mining. Coal-mine dust has been associated with a number of "material impairments of a miner's health or functional capacity."[3] In the qualitative risk assessment (QRA) for the proposed rule, MSHA has presented exposure response estimates for coal workers' pneumoconiosis (CWP), progressive massive fibrosis (PMF), severe emphysema, and non-malignant respiratory disease (NMRD). I understand that to address these risks, MSHA has published the proposed rule and solicited public comments. I further understand that the key provisions of the proposed rule include lowering the existing concentration limits for respirable coal-mine dust, providing for full-shift sampling, redefining the term ''normal production shift,'' providing for use of single-shift compliance sampling under the mine operator and MSHA's inspector sampling programs, establishing sampling requirements for use of the Continuous Personal Dust Monitor (CPDM), and expanding requirements for medical surveillance of miners.[4]

As part of the regulatory review process, MSHA has summarized its assessment of the economic costs and benefits of the proposed rule in the PREA and requested public comments. I have reviewed the PREA in the context of standard analysis for regulatory assessments. Based on my review, I have a number of significant concerns about the results and methods used to estimate compliance costs and benefits. In this report, I document the foundation for my concerns and present analyses that illustrate the potential significance of the concerns for the MSHA estimates of compliance costs and benefits. In addition, I identify specific areas in which the PREA substantially departs from guidance sponsored by the Office of Management

---

3 *See* Kogut, Jon, "Quantitative Risk Assessment in Support of Proposed Respirable Coal Mine Dust Rule," Delivered to MSHA under Contract DOLJ094R22516 (Sep. 2010) (the "QRA") at p. 3.

4 *See* Federal Register, "Department of Labor, Mine Safety and Health Administration, 30 CFR Parts 70, 71, 72, et al., Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors; Request for Comments" *available at* http://www.msha.gov/REGS/FEDREG/PROPOSED/2011PROP/2011-5127.PDF (last visited Apr. 18, 2011) at p. 12649.

and Budget (OMB) for federal agencies developing regulatory analysis in response to various federal authorities.[5]

A regulatory analysis that follows the OMB guidance and reflects the important uncertainties of and alternatives to the proposed regulatory changes matters for understanding the overall value of regulation to miners, the mining industry, and the broader economy. Resources used to meet a regulation that does not produce the anticipated health benefits efficiently for miners are not available to support other valued uses such as health investments, economic growth, or innovation in the energy sector.

Summary Comments on the MSHA Analysis of Compliance Costs

Regarding costs, inconsistencies with industry data or important omissions in the scope of compliance costs examined by MSHA indicate that its estimates are too low. This report contains analyses to demonstrate the importance of a select number of cost factors based on industry or MEC data that are inadequately addressed by the PREA. Importantly, some of these factors have the greatest impact on the most productive methods of mining and therefore could have implications for coal production and competitiveness beyond the mine-specific analysis that MSHA has conducted.

In some of the compliance costs examined by MSHA, there is an inadequate foundation for the assumed industry costs, affected mines, and the menu of incremental responses to achieve compliance. There are critical assumptions about the number of mechanized mining units (MMUs) that are likely to be affected by a required response that are not consistent with industry data. In one such example, MSHA states that only 50 MMUs are likely to be affected by proposed §75.332, which requires that "each MMU where mechanized mining equipment is being installed or removed to be ventilated by a separate split of intake air."[6] National Mining Association (NMA) data on super sections are presented in this report to understand the industry

---

5 *See* Office of Budget Management, Circular No. A-4, "Regulatory Analysis" (Sep. 17, 2003).

6 *See* PREA at p. 49.

perspective on this proposed change. These data indicate that the number of potentially affected MMUs is more than 250. Adjusting the MSHA analysis for the large number of potentially affected MMUs and adding variable costs to recover the delayed production impact from the proposed rule increases the MSHA estimate of total costs by a factor of 12.

MSHA's reported cost estimates are inconsistent with current industry data and/or assumptions. The PREA provides only limited analysis of uncertainty and does not develop sensitivity studies to address discrepancies in the key assumptions. In one such example, MSHA estimates a first-year cost of approximately $33 million for the industry to purchase the CPDMs and their warranties for underground mines.[7] MSHA's assumptions about the costs of the CPDMs are based on an assumed cost that is well below the cost documented in current industry invoices. In addition, the number of CPDMs necessary for each MMU is well above the MSHA assumptions, because MSHA does not adjust for the reliability of the devices. When the differences in costs and the differences in required units per MMU are adjusted for using industry data, the first-year cost estimate for the units and filters is increased by more than a factor of 2.

Importantly, MSHA's cost analysis contains very limited evaluation of the costs from production delays due to implementation of the proposed rule. Industry is concerned that MSHA has not accounted for the potentially large number of work stoppages that could result from immediate corrective actions initiated by single full-shift samples to determine noncompliance and a substantially increased number of compliance samples. An analysis of these production delays can be illustrated with industry data. Such an illustration is discussed below, and it suggests that these costs might be billions of dollars in the early years of implementation of the rules.

In addition, critical cost items were omitted from the economic analysis. These costs include the costs to cover new personnel such as the safety technicians needed to charge, maintain, and monitor the CPDMs. These workers might also be exposed to coal dust and the resulting countervailing risks have not been addressed in the MSHA report. Similarly, no analysis is

---

[7] *See* PREA at pp. 124 & 127.

reported regarding the potential increased safety issues for miners using the CPDMs. Finally, MSHA has not provided an analysis of the effectiveness or technological feasibility of particular required compliance responses. Two such examples apparently inconsistent with industry information are the use of permanent ventilation controls in certain operations or the addition of a new shaft for an existing mine under certain site conditions.

Summary Comments on the MSHA Analysis of Benefits

Regarding benefits, MSHA has departed substantially from a methodology based in reality for measuring the benefits of regulations to protect worker health. MSHA does not properly address the current health status of the coal miner population and new entrants to define the subject population to which the risk reductions can be applied. MSHA's total and annualized benefits are overestimated, for a number of reasons that I address in this report.

The basic framework used by MSHA to estimate the annualized benefits from the proposed rule uses a comparison between two hypothetical worker cohorts and is not a realistic description of the workforce for the benefits calculation. MSHA also has assumed numbers of workers in various occupational categories that likely overestimate the measured benefits. I present analysis in this report showing that, when the underground miner numbers are adjusted by data based on the current industry work force, the benefits estimate is reduced by 77 percent.

MSHA states that insufficient data are available to estimate benefits for the existing cohort of workers. Existing industry data do exist, however, that would support an analysis of avoided morbidity and mortality effects based on the existing work force and new entrants. The estimation problem is similar to that addressed in other industries with long-latency health effects. The general approach is presented and discussed in this report.

Moreover, MSHA reports no analysis of uncertainty regarding the magnitude of the benefits, although there is a sensitivity study of the timing of the benefits. Given the limitations of the health studies and the scientific debate regarding the risk at lower levels of exposure, sensitivity studies that vary the reduction in health risks are necessary for a better understanding of the expected benefits.

Finally, although MSHA acknowledges that compliance with the proposed rule is technically feasible, the PREA provides few details about the changes in the technical baseline expected over time. OMB guidance recommends an assessment of the technological changes to the baseline that would have occurred in the absence of the proposed regulation. MSHA indicates in the PREA that "significant progress has been made to reduce respirable coal mine dust levels in coal mines"[8] and that "most operations" might already be meeting the limits in the proposed rule.[9] If true, these statements might imply that, over the near term, there are no actual benefits to be measured from implementing the proposed rule to reduce the exceedance limits. MSHA should assess the direction of the technological and operational changes that would occur in the absence of the proposed regulation to define the technological baseline for the benefits estimation.

Summary Comments on Timing and Characterization of Estimated Costs and Benefits

Regarding conformity with the OMB guidance on regulatory analysis, the PREA provides very limited consideration of the large uncertainties or critical assumptions inherent in the cost or benefit estimates. It also does not generally provide information showing the timing of costs and benefits or the net present value once future values are discounted. In addition, the PREA does not provide a well-defined consideration of alternative regulatory schemes to lower miners' exposure to respirable coal mine dust. For example, at a minimum, OMB recommends examining options that are more and less stringent than the preferred options in the regulatory analysis. Analysis of alternatives approaches often identify modifications to the preferred rule that improve its acceptability and reduce its economic costs.

---

8 *See* PREA at p. 12.

9 *See* PREA at p. 39.

In this matter, the timing of the estimates of costs and benefits is important, because the large costs are near term—and therefore are more certain—and the benefits are not expected to be evident until a substantial portion of the current workforce has retired—and therefore are more uncertain. The time frame of the analysis is also vaguely defined. In the PREA, costs appear to be placed in no more than a ten-year time frame, and benefits are measured after 45 years of reduced exposure levels. This report presents an analysis of the stream of costs and benefits that shows the large differences in their placement over time. The comparison of costs and benefits should be made with the understanding that annual costs are immediately and realistically incurred for the proposed rule, while the annual benefits in the PREA are manipulations of the benefits that might be realized after 45 years.

The cost/benefit analysis in this report makes adjustments to benefits based on the proportion of the applicable age cohort of exposed miners and their longevity. Importantly, the consequences of these adjustments are to reduce the net present values (NPVs) and the annualized benefits substantially. For the example of underground mining, the NPV and annualized costs of the proposed rule *exceed* the value of the benefits when adjusted. The results of the Exponent analysis demonstrate that a more realistic description of the population at risk might not support the cost/benefit finding in the PREA.

1 Background and Specific Comments

1.1 Background on the PREA

1.1.1 Compliance Costs

To estimate the costs of compliance to the mining industry, the PREA contains a detailed listing of activities and costs for mines in each of three size categories, as determined by the number of employees per mine.[10] Compliance costs are addressed in the PREA in a number of different categories, including the installation of engineering controls, abatement costs, certification costs, use of continuous personal dust monitors (CPDMs), sampling methods, training, and citations. The PREA estimates first-year, annual, and annualized compliance costs.

In the PREA, MSHA estimates costs by stratifying mine size into 1 to 19, 20 to 500, and 501 plus employees. MSHA states that there is a "traditionally defined"[11] foundation for this particular stratification of mine size. A supporting analysis indicating the validity of this important uniform cost assumption should be included. For example, within underground and surface mines, labor costs by occupational category generally are assumed in the PREA not to vary by mine size or by geographic location. This is not typical of labor rates within industries.

The compliance costs in the PREA are often "based on the assessment of MSHA staff of the most likely actions that would be necessary to comply with the proposed rule."[12] The referenced assessment is not included with the report, and I consider below some examples of MSHA assessments that depart from industry data and have substantial implications for compliance costs.

---

10 MSHA has not provided an economic analysis to support its implicit assumption that compliance costs will be uniform for mines with employment levels from 20 to 500 employees. Regional variations in costs are also not addressed, which would be expected at least in the context of labor costs.

11 *See* PREA at p. 5.

12 *See* PREA at p. 41.

First year, annual, and annualized compliance costs are estimated. The first-year costs are estimated by MSHA to be approximately $72 to $93 million for the industry, and the annualized costs are estimated to be approximately $40 to $45 million.[13]

1.1.2 Benefits

To estimate the industry benefits of the proposed rules, the PREA estimates the value of injuries to miners' health that MSHA assumes will be avoided by implementing the proposed rules. MSHA estimates that these injuries will be avoided by the implementation of two to four provisions of the proposed rules. The benefits analysis in the PREA addresses the avoided health effects of (1) the reduced coal-dust standards (i.e., lowering the limit from 2.0 mg/m^3 to 1.0 mg/m^3), (2) changes to the basis for noncompliance (i.e., use of single samples rather than the average of five samples), (3) the requirement for full-shift sampling, and (4) changes in the definition of normal production shift. The PREA uses results from the QRA to provide estimates of the quantity of health effects avoided by comparison of two 73-year-old worker cohorts (one cohort that does not receive the benefit of the new standard compared to a second hypothetical cohort that does receive the benefit of the new proposed standard) after an assumed 45-year period of occupational exposure. The avoided injuries are "monetized" using estimates from the literature for willingness-to-pay values estimated for mortality and similarly severe morbidity risks.

MSHA estimates 3,483 to 4,300 avoided health injuries and approximately 106 to 131 avoided deaths as a result of the proposed rule.[14] Monetized and after 45 years, MSHA estimates benefits to be $7 to $9 billion in total constant 2009 dollars, or $99 to $197 million in what MSHA estimates to be the annualized benefits.[15]

---

13 *Ibid.*

14 *See* PREA at pp. 20-21, Tables III-2 & III-3.

15 *See* PREA at pp. 23-24, Table III-5. MSHA notes that the annualized benefits depend on its characterization of the stream of benefits over time. I address this in my review of the stream of costs and benefits later in this report.

1.2 Significant Inconsistencies with Industry Facts

OMB guidance recommends that a key element of a regulatory analysis is consultation with the parties affected to ensure assumptions about baselines, technologies, and likely responses are accurate. Based on my review of the PREA and discussions with industry representatives, I have identified several areas in which MSHA assumptions are currently inconsistent with industry data and perspectives. The MSHA analyses of compliance costs that are likely to have the largest consequences for the cost estimate include the costs of production delays at "super section" continuous miner operations, the costs of the CPDMs, and the technical feasibility of certain proposed responses for particular mining operations. These examples are reviewed below.

1.2.1 Super Sections and Production Delays

MSHA analysis of the compliance costs for ventilating each MMU by a single split of air relies on an assumption about the total number of MMUs that would be affected. Proposed §75.332 would require "each MMU where mechanized mining equipment is being installed or removed to be ventilated by a separate split of intake air…"[16] MSHA estimates that 50 MMUs would likely be effected by this requirement of the proposed rule. Industry data indicate that MSHA's assumption is too low, as shown in Table 1 below. These data were collected by the NMA from a group of twelve operators. The operators were asked to report the number of MMUs operated in working sections with multiple MMUs ventilated by either a single split of air or multiple splits not separated by permanent ventilation controls.

[16] *See* PREA at p. 49.

Table 1. Industry super section data v. MSHA estimate

Company	Count of MMUs in Super Sections[1]	MSHA Count[2]
Alpha Natural Resources	22	
Alliance Coal	39	
Arch Coal	1	
Cline Group	10	
CONSOL	12	
ICG	14	
James River	5	
Massey	96	
Murray Energy	6	
Patriot	46	
Peabody	12	
Walter Energy	2	
Total	**265**	**50**

Notes:
1. Source for data: NMA. "Super Section" is defined as a mining section ventilated by either a single split of air or multiple splits not separated by permanent ventilation controls on which multiple MMUs are being operated simultaneously.
2. MSHA data taken from PREA at p. 50.

As I understand it, MSHA's proposed rule would not allow more than one production crew to operate on MMUs with multiple sets of mining equipment unless permanent ventilation controls are installed, thereby separating the MMUs.[17] If permanent ventilation controls are not installed, then compliance with the proposed rule will require an operational change as the one production crew switches to the second set of mining equipment. In MSHA's view, this will cause a 5 percent production delay for only one year until the operations are reconfigured. MSHA estimated the total cost of this delay for the 50 MMUs to be $6.2 million and estimated the annualized cost to be $1.5 million. In MSHA's analysis, approximately 418,000 tons of production would be delayed.[18]

[17] *Ibid.*

[18] *See* PREA at p. 50. Value calculated as 334,134 ton per year per MMU * 5 percent (0.05) production delay * 25 MMUs = 417,667 tons.

MSHA analysis of production delays relies on an assumption that the lost production is recovered in five years. As I understand it, this assumption rests on an implicit assumption that the average remaining life of a super section MMU is five years.[19] Even assuming this is true; MSHA has not included in the present analysis the extra variable costs that will be incurred to recover the delayed production. Delayed production is costly, not only because revenue is postponed, but also because variable costs (labor, rental equipment, energy costs, etc.) are fixed—and therefore incurred—in the short run of the delay and will have to be incurred *again* when the delayed production occurs. In other analysis of production delays, MSHA recognized that these variable costs were also an incremental burden from the delay and therefore should be included in the calculation of the production delay.[20] In the present analysis, the number of affected MMUs is increased to 265, and the increased variable costs are included to recover the delayed production. Without any other modifications to the MSHA assumptions, these changes raise the estimated total cost of the proposed rule to $73 million, the delayed production tons to more than 2 million, and the annualized value to $18 million.[21]

1.2.2 Continuous Personal Dust Monitor Quantities and Costs

MSHA assumptions and industry perspectives differ substantially on the costs of the CPDMs. In the PREA, MSHA estimated the number of CPDMs that the industry will require under the proposed rule by occupational category. Table 2 below displays the average number of CPDMs per MMU using information from the PREA for the total number of underground MMUs and

---

19 I note that if the remaining life of an average super section MMU exceeds five years, the costs of the production delays would be larger than those calculated by MSHA or Exponent.

20 *See* U.S. Department of Labor, Mine Safety and Health Administration, Office of Standards, Regulations, and Variances, "Preliminary Regulatory Economic Analysis For The Proposed Rule Concerning Determination of Concentration of Respirable Coal Mine Dust and The Proposed Rule for Verification of underground Coal Mine Operators' Dust Control Plans and Compliance Sampling for Respirable Dust," Document Numbers RIN-1219-AB18 & RIN-1219-AB14 (Feb. 2003) (the "2003 PREA") at pp. 194-195. In the 2003 PREA, MSHA implicitly assumed that only half the revenue is recoverable due to the additional variable costs of production, which were assumed to be 50 percent of revenue. The same assumption is used for my calculations.

21 Recognizing that only half of the revenue is recovered, Exponent took 334,134 tons per year * 265 MMUs * 0.5 * 5 percent (0.05) decrease in production per shift *$51.35 per ton. This results in $113,670,298 in revenue. Exponent then subtracted the discounted value $40,523,461 (0.5*113,670,298*0.713) from this to account for revenue recouped. This gives $73,146,837 in lost revenue as a result of the delayed production. Annualized, this results in $73,146,837*0.244 = $17,847,828. The delayed production tons are calculated as 334,134*265*0.5*0.05 = 2,213,638.

the total number CPDMs required at underground operations under the proposed rule for the Designated Occupations (DO) and the Other Designated Occupations (ODO).

Table 2. MSHA average CPDMs per MMU

Mine Size	Number of Shifts per Day	CPDMs for DOs[1]	CPDMs for ODOs[1]	Number of MMUs[1]
1 to 19	1	69	81	69
	2	24		12
20 to 500	1	45	662	45
	2	1178		589
	3	148		74
501+	2	6	24	3
	3	178		89
Total		**1648**	**767**	**881**
Total CPDMs for DOs per Total MMUs[2]				1.87
Total CPDMs for ODOs per Total MMUs[3]				0.87
Total CPDMs per MMU				**2.74**

Notes:
1. Counts of CPDM units estimated & count MMUs taken from the PREA, p. 122.
2. Calculated by dividing the total number of CPDM units estimated by MSHA for DOs by the total number of MMUs (1648/881 = 1.87).
3. Calculated by dividing the total number of CPDM units estimated by MSHA for ODOs by the total number of MMUs (767/881 = 0.87).

Exponent and Murray Energy Corporation analysis have produced the following alternative estimate, shown in Table 3, for the number of units necessary per underground MMU under the proposed rule. This estimate is conservative given other industry data.[22]

[22] *See* Watson, Mark and Health Lovell, "National Mining Association, Analysis of MSHA Coal Dust Sampling Data Base & The Impact Of The MSHA Proposed Rule," PowerPoint slides presented to MSHA panel at Arlington, VA public hearing on the proposed rule (Feb. 15, 2011) (the "Alliance Coal Presentation") at p. 43.

Table 3. Exponent CPDM estimate

Sampling Category	Number of CPDM Units/MMU
Designated Occupation (DO) (1 per MMU)[1]	2
Other Designated Occupation (ODO) (2 per MMU)[1]	2
Sub - Total	**4**
Mark-Up for Maintenance/Reliability[2]	25%
Total	**5**

Notes:
1. Analysis provided by Murray Energy Corporation. *See* "CPDM requirements under the proposed Dust Rule.dox".
2. Rate based on Exponent analysis.

The estimate above includes two CPDMs for the ODO sampling. This is based on the requirement to sample continuous shifts over a 14-day period. In order to perform this sampling, two CPDMs might make sense for reliability concerns alone,[23] but would certainly be necessary for operations with multiple shifts per day. MSHA data indicate that 87 percent of MMUs have two or more shifts per day.

In addition to estimates of quantity, the PREA also presents information concerning the costs of CPDM units, their warranties, and their filters. Table 4 compares industry data for these costs to MSHA estimates. For this comparison, areas of agreement in the assumptions between the Exponent and the MSHA analyses are indicated by the single value reported and centered between the two right columns. CPDMs purchased for supplementary controls or for monitoring Part 90 miners are not included in these estimates.

[23] I understand that the industry is increasing from a current level of 250 CPDMs in application to thousands under the proposed rule. *See* Thermo Fisher Scientific, "2011 PDM3600 CPDM Collaborative Purchase Program," PowerPoint slides, (2011) ("Thermo Fisher Slides") at p. 4. Whether this steep increase is the units produced will have important implications for the unit reliability is an additional cost sensitivity that MSHA should consider.

Table 4. Net present value of CPDM costs (2009$)

Calculation	Label	Exponent Estimate	MSHA Estimate
[A]	**Cost/CPDM Unit**	**$12,900**	**$10,000**
[B]	Five-Year Protection Plan	$2,875	
[C=A+B]	Total Cost per Unit	$15,775	$12,875
[D]	Total MMUs	881	
[E]	**CPDM Units per MMU**	**5**	**2.7**
[F=D*E]	Total CPDM Units	4,405	2,415
[G]	Discount Factor for ODO Units	0.903	
[H=C*F/2]	Cost of CPDM Units for DO Sampling	$34,744,438	$21,218,000
[I=C*F/2*G]	Discounted Cost of CPDM Units for ODO Sampling	$31,374,227	$8,917,238
[J=H+I]	**Total "First-Year" Cost of CPDM Units**	**$66,118,665**	**$30,135,238**
[K]	Cost/Filter	$6.50	$5.50
[L]	Total Number of "First-Year" Filters	750,000	763,082
[M=L*0.28]	Number of "First-Year" ODO Samples	210,000	215,432
[N=L*0.72]	Number of "First-Year" DO Samples	540,000	547,650
[O]	Discount Factor for ODO Filters	0.859	
[P]	Discount Factor for DO Filters	0.925	
[Q=K*M*O]	Cost of Filters for ODO Sampling	$1,172,535	$1,017,808
[R=K*N*P]	Cost of Filters for DO Sampling	$3,246,750	$2,786,169
[S=Q+R]	Total "First-Year" Filter Cost	$4,419,285	$3,803,978
[T=J+S]	**Total "First-Year" Cost**	**$70,537,950**	**$33,939,216**

Notes:

1. [A] taken from "Thermo Fisher Scientific: 2011 PDM3600 CPDM Collabrative Purchase Program" at p. 2. [B] & [K] taken from "CPDM Actual Cost.pdf" at p. 6. This document was provided to Exponent by Murray Energy Coropration and consists of pdf scans of sales reciepts for CPDM units, warranties and associated filters. [K] is the $130 cost of a box of 20 filters divided by 20.
2. [D] taken from the PREA at p. 44.
3. [E] based on infromation from "CPDM requirements under the proposed Dust Rule.docx" at p. 1, provided by Murray Energy Corporation.
4. [G] taken from the PREA, Table V-24 at p. 124.
5. [L] taken from "Testimony of George Ellis, President, Pennsylvania Coal Association, Proposed Rulemaking on Respirable Coal Mine Dust, February 8, 2011.docx" at p. 3.
6. [M] & [N] calculated according to the proportion of samples alloted to ODO and DO respectively out of the Total Number of "First-Year" Samples in the "MSHA" column.
7. [O] & [P] taken from the PREA, Table V-25 at p. 127.
8. All costs in "MSHA" column taken from the PREA p. 123-124 & 125-127.

The more than two-fold difference between the net present value of costs is due to the difference in assumptions about the number of CPDMs required under the proposed rule and the cost of the units. Exponent's estimate reflects more units to sample the occupational categories—a reflection of the point about shifts—and more units to address reliability. Exponent's cost per unit is based on the list price of the units and invoices received from MEC. I understand that Thermo Fisher Scientific recently offered a "collaborative purchase program" to the industry. Price reductions from this program depend on the total units ordered by industry by June 20, 2011.[24] Using the lowest hypothetical Thermo Fisher Scientific price ($8,325 per unit), however, only reduces the Exponent estimate to $51 million, and it remains substantially more than the MSHA estimate.

1.2.3 Technical Feasibility

1.2.3.1 Ineffective Technology

Industry is concerned that among the engineering controls included in the PREA are technologies that have proven to be ineffective for the purpose of lowering respirable dust. For example, returning to requirements affecting super sections, proposed §75.332(a)(1) would require that "each MMU where mechanized mining equipment is being installed or removed to be ventilated by a separate split of intake air directed by overcasts, undercasts or other permanent ventilation controls."[25] The PREA contains no analysis of the conditions under which these controls are effective, or even feasible, under current mining operations.

1.2.3.2 Infeasible Technology

Based on discussion with MEC, there are control measures indicated in the PREA that are technologically infeasible for some operations. For example, MSHA states that, in the case of four mines operating longwall MMUs in District 9 with only two entries, "it may be possible that under the proposed rule one of these mines would find it necessary to sink an additional

[24] *See* Thermo Fisher Slides at p. 2.

[25] *See* PREA at p. 49.

shaft and install additional fan capacity to provide the necessary ventilation."[26] MSHA estimates that the cost of sinking an additional shaft is $10 million, or $1.4 million annualized over ten years. MEC representatives are concerned that District 9's geologic constraints make the sinking of an additional shaft nearly impossible from a cost and permitting perspective. The depths of these mines are substantial, and the MSHA suggestion would require sinking a shaft of approximately 3200 feet in vertical depth in the MEC case. In addition, there is no explanation in the PREA as to why only one of the affected mines would incur this substantial cost. In one of the sensitivities to the cost analysis that I consider below, I examine a case in which all four mines incur the cost, assuming that such an investment is effective to comply with the proposed rule.

1.3 Omitted Cost Categories

OMB guidance recommends that a regulatory analysis address omitted costs and countervailing risks. My review has identified two substantial areas of costs not addressed in the PREA. First is the cost of work stoppages if the proposed rule requires a corrective action by mine management for every single-sample result that is at or above the citation threshold. Second is the cost of additional personnel to operate, distribute, monitor, and repair the CPDMs, as well as manage the sampling data. In addition, there are countervailing risks from the widespread use of the CPDMs that have not yet been addressed by MSHA. These omitted costs are reviewed below.

1.3.1 Work Stoppages

My review has identified that MSHA has not estimated any costs due to greater noncompliance with the applicable dust standard. MSHA has not presented an analysis to address the reasonable assumption that, once implemented, the proposed rules will lead to much greater likelihood of noncompliance at the most productive mining operations. This increase in the non-compliance rate would be due to the more stringent exceedance limits and the greatly

26 *Ibid.*

expanded level of sampling in the mines under the proposed rule. Costs related to a greater likelihood of non-compliance include penalties resulting from citations, and work stoppages for corrective actions.

The PREA states that "MSHA did not estimate the cost of the penalties resulting from the citation because the Agency considers penalties to be transfer payments (as are taxes and subsides) and not to be social costs."[27] It is well recognized, however, that penalties can have social impacts if they affect dynamic processes over time.[28] Frequent and/or large penalties can affect mine operations, industry structure, and innovation, and if they are anticipated under a proposed rule, their effects should be included in the compliance cost analysis.

Industry is concerned that the majority of costs not examined by MSHA for the proposed rule that will result from citations or their avoidance are likely to come in the form of work stoppages or delays due to implementing proactive or corrective actions. These delays have substantial effects on the revenue and production levels of the mines. During the Public Hearing on February 15, 2011, in Arlington, Virginia, there was a discussion about whether citations would be issued by MSHA for single-sample or weekly exceedances.[29] In the PREA, MSHA assumes that the sampling period for the CPDM data and the compliance determinations are weekly.[30] Nonetheless, the PREA indicates that "the CPDM would provide mine operators with information about the actual exposures of the DOs on a real-time basis and allow mine management to be proactive in taking corrective action *during the shift* to prevent possible overexposures."[31] My understanding from industry representatives is that this issue remains unresolved.

---

27 *See* PREA at p. 64.

28 *See* Environmental Protection Agency, "Guidelines for Preparing Economic Analyses," EPA Report number 240-R-10-001 (Dec. 2010) at p. 8-8.

29 *See* Mining Safety and Health Administration, "Transcription of Proceedings in the Matter of: Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors; Proposed Rule." Transcript of public hearing in Arlington, VA. (Feb. 15, 2011) at pp. 166-171.

30 *See* PREA at pp. 62-63.

31 *See* PREA at p. 61. Emphasis added.

To illustrate the potential magnitude of these costs and production losses, Exponent has conservatively assumed that exceeding or nearing exposure limits will require immediate corrective action and work stops on the MMU for one hour. Exponent used information gathered from various industry sources to construct a simple simulation model of the work stoppages in underground mines. The first component of this model addresses the number of samples to be taken under the proposed rule for underground mines using different mining methods. Only DO and ODO sampling is considered to simplify the modeling. Table 5 shows the annual number of samples that would be taken at underground mines under the proposed rule in the first 12 months after both DO and ODO sampling by CPDMs is required. It is worth noting that, if the proposed rule essentially requires mine management to take corrective actions based on every single-sample, then there are more than 730,000 opportunities to approach or exceed the applicable limit. In contrast, MSHA has projected only 45,812 compliance determinations for its analysis of citations, based on the assumption that sampling periods at each MMU are weekly.[32]

Hourly production rates were obtained from MEC's longwall operations and are shown in Table 6. Table 7 summarizes other production assumptions by mining method taken from the previous tables, MSHA estimates, and other industry data as identified in the table's notes.

---

32 *See* PREA at p. 62.

Table 5. Annual samples

	Calculation	Number of Shifts & Type of Sampling	Mining Method: Longwall	Mining Method: Continuous Miner
[A]	Number of MMUs[1]		38	848
[B]	Composition of Shifts per Day by Mining Method[2]	2 Shifts	-	594
		3 Shifts	38	254
[C=A*B]	Number of Shifts by Mining Method	2 Shifts	-	1,187
		3 Shifts	114	763
[D]	DO & ODO Composition by Mining	DO	1	1
		ODO	1	2
[E]	Days Sampled per Year[3]	DO	329	242
		ODO	56	56
[F=C*D*E]	Samples per Year	DO - 2 Shifts	-	287,302
		DO - 3 Shifts	37,449	184,694
		ODO - 2 Shifts	-	132,966
		ODO - 3 Shifts	6,384	85,478
	Total Samples by Mining Method		43,833	690,442
	Total Annual Samples		**734,275**	

Notes:

1. Number of MMUs sourced from data provided to the NMA by MSHA.
2. Assumes 70 percent of Continuous Miner MMUs operate 2 shifts daily and 30 percent operate 3 shifts daily. Assumes all Longwall MMUs operate 3 shifts daily.
3. ODO sampling occurs 14 consecutive days per quarter resulting in 56 sampling days per year. DO sampling occurs every production day. For the Longwall MMUs this is calculated as 365*0.9 = 329. For the Continuous Miner MMUs, 242 DO days sampled per year based on Murray Energy information.

Table 6. Longwall production rate

Operation[1]	Clean Tons[2]	Uptime Minutes[2]	Uptime Hours[2]
American Energy Corporation - Century Mine	5,369,555	391,239	6521
The American Coal Company - New Era Mine	3,751,828	282,015	4700
The American Coal Company - New Furture No. 5 Mine	1,798,352	225,117	3752
The Ohio Valley Coal Company - Powhatan No. 6 Mine	5,567,477	345,102	5752
UtahAmerican Energy, Inc. - West Ridge Mine	2,500,145	211,563	3526
Total	18,987,356	1,455,036	24,251
Clean Tons per Uptime Minute[3]			13
Clean Tons per Uptime Hour[4]			**783**

Notes:

1. Data provided by Murray Energy Corporation.
2. "Clean Tons" are defined as tons produced once the coal has been cleaned of debris. "Uptime Minutes" and "Uptime Hours" defined as time spent by MMUs cutting coal.
3. Calculated as 18,987,356/1,455,036 = 13.
4. Calculated as 18,987,356/24,251 = 783.

Table 7. Production assumptions

	Mining Method			Total Adjusted Underground Production[4]
	Longwall Production	Continuous Miner for Longwall Production	Other Continuous Miner Production	
Tons[1]	133,132,800	33,283,000	160,760,000	327,176,800
% Underground Production	40.69%	10.17%	49.14%	100.00%
Tons Per Hour of Production[2]	783	65	102	
Revenue per Hour Production[3]	$43,668	$3,625	$5,689	

Notes:

1. Longwall Production tons and Continuous Miner for Longwall Production tons calculated based on information from the Department of Energy report EIA-0584 (2009) at Table 3. U.S. Total tons for Longwall mines given as 166,416,000 tons in 2009. The report states that 80 percent of this production (133,132,800 tons) is attributable to Longwall MMUs and the remaining 20 percent (33,283,000 tons) is attributable to Continuous Miner MMUs associated with these Longwalls. Tons for Other Continuous Miner Production also taken from the Department of Energy report EIA-0584 (2009) at Table 3.
2. Longwall Tons Per Hour of Production and Continuous Miner for Longwall Tons Per Hour of Production provided by Murray Energy Corporation. Other Continuous Miner Tons Per Hour of Production based on MSHA estimates.
3. Values calculated by multiplying the respective Tons Per Hour of Production by an avaerage Revenue per Ton value of $55.77. This value provided by Murray Energy Corporation.
4. "Total Adjusted Underground Production" does not include "Conventional and Other" methods of mining from the Department of Energy report EIA-0584 (2009) at Table 3.

Using MSHA data provided to Exponent by Alliance Coal for calendar year 2010, Exponent obtained counts of samples exceeding a 1.0-mg/m^3 standard and a 2.0-mg/m^3 standard for various DO and non-DO occupational categories. These data were used to estimate counts of samples that would trigger a one-hour shut down in the simulation model. Data from 2010 were used to ensure that the most recent technological conditions were used in the baseline rates.

A number of assumptions have been made to simplify the analysis. The analysis did not adjust for full-shift sampling, which would have increased the exceedance rates. It did not distinguish data for MMUs required to comply with reduced standards due to the presence of quartz. Distinguishing these data likely would have increased the proportion of samples for the non-quartz MMUs that exceeded the applicable standard.[33] The simulation does not adjust for the transition from the 1.5-mg/m^3 standard to the 1.0-mg/m^3 standard after 24 months, but it is capable of accommodating this adjustment. Finally, the simulation does not include an adjustment for delayed production recovery. This adjustment is not included because of the potential variation among the mines for the recovery of the production. An alternative method based on MSHA's analysis of production delays in the 2003 PREA could be applied to the estimates to obtain a general sense of the reduction in the cost from production recovery. This method would reduce the longwall lost revenues by 25 percent and the continuous miner revenues by 36 percent.[34]

Table 8 shows the resulting revenues and tons of production lost from work stoppages assuming that the same percent of samples would approach or exceed the proposed standard in the third year after the implementation of the proposed rule.

---

[33] A more precise analysis would have been possible with information on the applicable standard. I understand that data on the applicable standard for each sample in the MSHA database was requested by Alliance Coal, but to date, Exponent has not received this information.

[34] These percentages are based on the MSHA analysis indicating that revenues after recovery and additional variable costs equal (R – (.5 * R * .508) = R * .75) for longwall operations and (R – (.5 * R * .713) = R * .64) for continuous miner operations.

Table 8. Work stoppages — near term (2009$)

		Longwall Production	Continuous Miner for Longwall Production	Other Continuous Miner Production	Count	Total Losses[4]
Existing Standard	Samples Exceeding 2.0 mg/m³ Standard[1]	102	232	1,132	1,466	
	DO Percent[2]	6%	5%	5%		
	ODO Percent[2]	2%	1%	1%		
	Revenues Lost[3]	$4,439,652	$840,781	$6,441,675		$11,722,108
	Tons Lost	79,606	15,076	115,504		210,187
Proposed Standard	Samples Exceeding 1.0 mg/m³ Standard[1]	20,366	21,910	106,972	149,249	
	DO Percent[2]	50%	21%	21%		
	ODO Percent[2]	26%	13%	13%		
	Revenues Lost[3]	$889,350,376	$79,424,840	$608,516,463		$1,577,291,678
	Tons Lost	15,946,752	1,424,150	10,911,179		28,282,081
Annual Revenue Lost Under Proposed Regulations due to Work Stoppages						$1,565,569,570
Annual Tons Lost Under Proposed Regulations due to Work Stoppages						28,071,895

Notes:

1. Data sourced from Excel File "DUST_Data_(2001_thru_2010)_(2-11-11).xls". This file contains MSHA sample data provided to Exponent by Alliance Coal. Samples are for 2010 and underground mines only.
2. Percent is the percent of total 2010 operator samples that exceeded the described standard for each production method represented in the above cited MSHA data. This data does not distinguish between types of continuous mining and so the continuous miner samples were allotted according to the percent of total continuous miner tons produced by each method in 2009. Therefore 17 percent were allotted to Continuous Miner Production for Longwall Production and 83 percent were allotted to Other Continuous Miner Production.
3. Reveues Lost are calculated as Samples Exceeding Standard*Revenue per Production Hour.
4. Total Losses under the Existing Standard reflect a hypothetical baseline assuming that single-sample compliance is used under the existing regulations.

The results above indicate that for a 12-month period with single-sample compliance, and beginning soon after the substantial expansion of dust concentration sampling, costs due to work stoppages could approach $1.6 billion. Production losses would be nearly 10 percent of normal production, or approximately 28 million tons. Importantly, MSHA has indicated that its revenue screening test for economic feasibility is 1 percent of annual revenues.[35] These costs approach 9 percent.[36]

The Exponent results—based on one-hour work stoppages—are more conservative than other industry analysis using full-shift work stoppages. Alliance Coal presented an analysis of

[35] *See* PREA at p. 158.

[36] This is based on $1.6 billion/$17 billion.

possible plan changes under the proposed rule at the aforementioned Public Hearing on February 15, 2011.[37] Alliance estimated that, based on its Mine 6 operations, even at 96% compliance, the expanded sampling would lead to an average of two plan changes per day and production downtime of 588 shifts per year. The production downtime would result in lost revenues of approximately $30 million for 18 MMUs, or approximately $1.7 million per MMU. The analysis above indicates a cost of $800,000 per continuous miner MMU.

It is also important to note that, under existing standards, continuous miner operations account for the majority of the hypothetical baseline revenues lost. Under the proposed rule, longwall operations are responsible for the majority of revenues lost, because they are expected to have much higher exceedance rates than other operations under the proposed reduced standards. In addition, an hour lost in the longwall operations is much more costly than other operations because they are so productive. This analysis suggests that a disproportionate burden of the proposed rule could fall on the most productive mining operations.

Exponent also simulated a scenario to capture the long-term implications of the reduced standards and the expanded sampling. Table 9 shows the revenues and tons of production lost from work stoppages should the industry, over time, adjust to the new regulation and exceed the proposed standard at the same rate as under the existing standard. Even under the long-term assumptions, the lost revenues and tons are substantial due to the greatly expanded number of samples.

[37] *See* Alliance Coal Presentation at pp. 47-48.

Table 9. Work stoppages — long term (2009$)

		Longwall Production	Continuous Miner for Longwall Production	Other Continuous Miner Production	Count	Total Losses
	Samples Exceeding 1.0 mg/m³ Standard[1]	2,325	4,177	20,392	**26,893**	
Proposed Standard	DO Percent[2]	6%	5%	5%		
	ODO Percent[2]	2%	1%	1%		
	Revenues Lost[3]	$101,542,936	$15,140,323	$115,998,164		**$232,681,423**
	Tons Lost	1,820,745	271,478	2,079,938		**4,172,161**
Annual Revenue Lost Under Proposed Regulations due to Work Stoppages						**$220,959,315**
Annual Tons Lost Under Proposed Regulations due to Work Stoppages						**3,961,974**

Notes:

1. Data sourced from Excel File "DUST_Data_(2001_thru_2010)_(2-11-11).xls". This file contains MSHA sample data provided to Exponent by Alliance Coal. Samples are for 2010 and underground mines only.
2. Percent is the percent of total 2010 operator samples that exceeded the described standard for each production method represented in the above cited MSHA data. This data does not distinguish between types of continuous mining and so the continuous miner samples were allotted according to the percent of total continuous miner tons produced by each method in 2009. Therefore 17 percent were allotted to Continuous Miner Production for Longwall Production and 83 percent were allotted to Other Continuous Miner Production.
3. Reveues Lost are calculated as Samples Exceeding Standard*Revenue per Production Hour.

1.3.2 Additional Personnel

Information provided by industry suggests a need for additional Safety Technicians on site at underground operations just to conduct exposure measurements with CPDM units. Information from MEC indicates that the following additional work efforts will be required under the proposed rule to implement the use of the CPDMs in the mines:

- CPDM Units must be started approximately 30 minutes prior to the beginning of each shift for warm-up and diagnostic testing.
- If the machine fails to start properly, the sequence must be initiated again. Therefore, it is estimated that one hour and fifteen minutes will be needed to get all machines ready for use on the following shift.

- The CPDM units must then be distributed to each DO in various staging areas of the mine.

- A Safety Technician would have to observe workers at different sections of the mine to ensure that the CPDM units were being used properly and their readings monitored.

- Data from multiple CPDM units would need to be downloaded and documented at the end of each shift.

This process is expected to occur with every shift. Assuming four to six CPDM units per shift distributed across various DOs, and three shifts, this process is likely to require multiple technicians per mine. Information from Alliance Coal indicates that these personnel would cost approximately $100,000 per year.[38]

The costs of hiring additional personnel to perform these tasks are not addressed in the PREA. In addition, the PREA does not address the subsequent countervailing risks to these additional personnel who themselves will be subjected to coal-mine dust exposures.

1.3.3 Health and Safety Costs

Another likely area of countervailing risks not addressed in the PREA is the additional ergonomic considerations associated with the use of the CPDM units. Comments submitted to MSHA by Dr. Torma-Krajewski indicate that MSHA should examine the following factors in relation to the benefits of deploying the CPDM broadly:[39]

- Size and weight of the CPDM

- Light cord/sample hose

- Attachment to the miner's belt

---

[38] *See* Alliance Coal Presentation at p. 45.

[39] *See* Torma-Krajewski, Janet, "Written Comments for Submittal," Draft written comments submitted to MSHA on the ergonomics of the proposed rule (Apr. 19, 2011).

- Additional musculoskeletal disorders (MSDs) that might result from the use of a CPDM unit on a continuous basis
- Acute injuries that could result because of distractions created by the CPDMs.

MSHA reports no analysis for the health and productivity costs that these conditions might imply for miners, nor a foundation for omitting them.

1.4 Benefits

When estimating the costs of the proposed rule, MSHA assumes that the existing workers and existing infrastructure are in place. When calculating the benefits, however, MSHA adopts a different model—one that compares a cohort of works under a continuation of existing regulations to a hypothetical new cohort *only* exposed to the proposed standards. As a result, MSHA's benefit model likely overestimates the benefits obtainable from the proposed rules for the existing workforce, even assuming that the MSHA exposure-response models are correct.[40]

MSHA's benefits model assumes the following:

- Only two cohorts
- Status quo exposure for 45 years for the baseline cohort
- Reduced coal-dust limits and increased sampling with a cohort not previously exposed.

These assumptions fail to reflect that the coal industry relies heavily on experienced workers. As applied by MSHA, the assumptions impose a restricted view of the avoided injuries such that they are only relevant for a cohort that is 73 years old after 45 years of exposure.[41] If the

[40] In the analysis that follows, I do not challenge these models, but I understand that there is a fair amount of scientific uncertainty regarding their foundations and results.

[41] *See* QRA at p. 49. "All risks are calculated for miners 73 years of age, who have previously accumulated 45 years of occupational coal mine dust exposure."

45-year exposure ends 45 years from 2011, and the exposed cohort is 73 at the end of the exposure period, then the cohort is 28 years old in 2011.

Alternatively, there are standard methods for estimating the benefits of avoided health injuries or illness that provide a different framework. The following points outline this methodology:

- Define the existing worker age cohorts, exposures (and their changes over time in the absence of the proposed rule), and turnover conditions.
- Define the age cohorts, exposures, and turnover conditions for new entrants.
- Control for other causes of injuries and adverse conditions.
- Simulate injuries due to current exposures (status quo).
- Identify how exposures change from implementation of the new regulations.
- Define the last calendar year of exposure in which status quo exposures exceed the proposed standards.
- Simulate injuries due to reduced exposures (assumed from proposed standards).
- Measure differences between the status quo and the proposed standards.

The benefits presented in the PREA are based on a difference between the status quo and the proposed reduced standards, but they do not account for characteristics of the living current cohort populations or the new entrants. As a result, the benefits are likely to be over-estimated, especially because MSHA used the *current number* of coal miners to be in each occupation examined for the living population of 73 year olds after 45 years of exposure in, presumably, the year 2056.[42]

Figure 1 illustrates the problem with MSHA's estimation method and the role of worker turnover. MSHA has assumed that the monetized value of the prevented health injuries begins

---

42 *See* PREA at p. 17.

with workers in year one and continues until the end of the 45-year exposure period. MSHA is measuring the full difference between the blue line (which measures the value of injuries under the existing rule) and the red line (which measures the value of injuries under the presumably more protective rule). Realistically, given that the current work force already has accumulated exposures, the reduction in the standard will have little, if any, effect on their risks of disease, at least in the short term. As a result, in year one, there is no difference to be measured in the value of the injuries. This is shown by the green line, which equals the level of the blue line in year one. As time moves forward, the share of the work force that has never been exposed to the existing regulations increases, and existing workers are accumulating measurably less exposures. As a result, the difference between the value of health injuries under the existing rule and the value under the presumably more protective rule increases. This is reflected by the decline in the green line to the level of the red line and reflects the full benefit of the proposed rule. The area marked as "A" measures the over-estimate of benefits if the accumulated exposure and turnover dynamics are ignored.

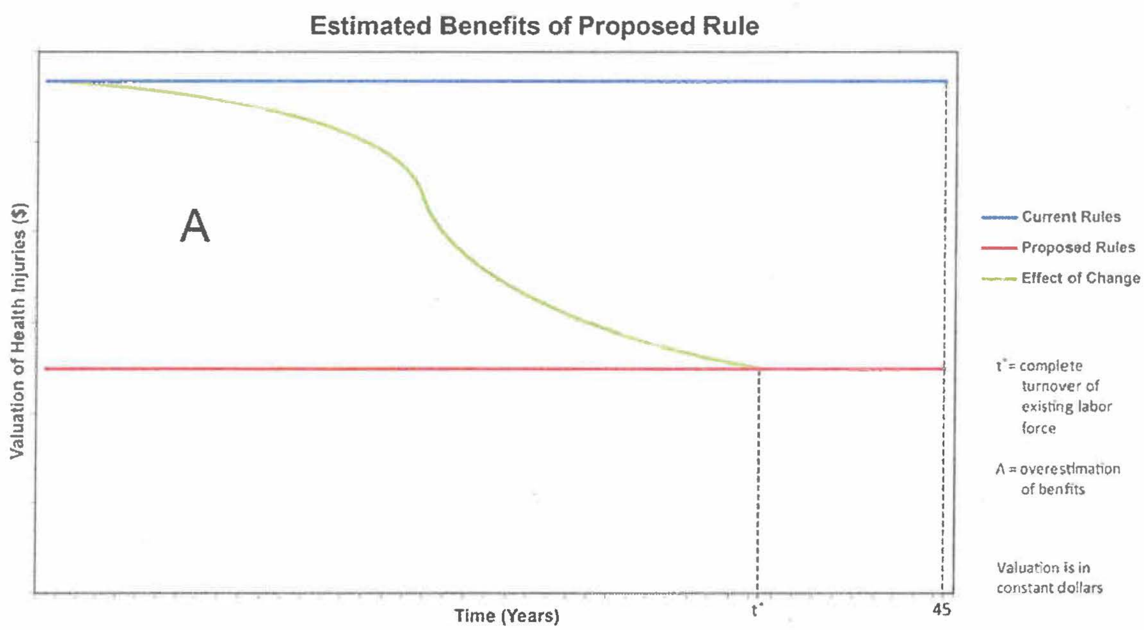

Figure 1. Over-estimation of benefits

This issue of placing the living cohort populations at risk in the context of the existing work force has been addressed previously by MSHA. In the 2003 PREA, MSHA states the following:

> Because these diseases typically arise after many years of cumulative exposure, allowing for a period of latency, and the pre-existing occupational exposure histories of members of the current coal mining workforce, the beneficial effects of reducing exposures are expected to become evident only after a sufficient time has passed so that the reduction in cumulative exposure could have its effect. ***The total realized benefits would not be fully evident until after the youngest of today's underground coal miners retire.*** If the size of this workforce substantially changed in the future and the projected pattern of prevented overexposures remained the same, the number of cases of prevented simple CWP and PMF would need to be adjusted to account for the change. (emphasis added)[43]

In the current PREA, MSHA admits that "MSHA does not have data from which to predict disease latency, thus it is not clear how soon the benefits estimated in this analysis will accrue,"[44] and that "MSHA's analysis compares two separate cohorts who experience two different life-time exposure scenarios, thus it is not clear whether the actual cohort of miners (who already have prior exposures) are likely to experience the magnitude of "avoided" adverse health effect documented."[45]

I disagree with MSHA's conclusion that it did not have the data to address the estimated impacts for the existing worker population or to conduct a proper economic analysis of the estimated benefits of the proposed rules. The risk models that MSHA is using to measure the benefits based on its hypothetical worker cohorts can be applied to data on the existing labor force and new entrants over time. The MSHA models estimate risks based on age of the worker and cumulative exposures, among other variables such as smoking and coal rank.[46] With information about the living cohort populations in each future year by age, years since first

---

[43] *See* 2003 PREA at p. 23.

[44] *See* PREA at p. 24.

[45] *Ibid.*

[46] *See* QRA at pp. 129-138.

exposure, and occupational category (to account for different exposure levels), these models can be applied to a realistic description of the actual work force. This type of analysis has been used routinely to estimate changes in occupational exposures to asbestos for many years.

The occupational health effects methodology for asbestos exposures builds on the approach and data published by William J. Nicholson, George Perkel, and Irving Selikoff (hereinafter referred to as "Nicholson"),[47] which is organized by industry. The Nicholson approach is the generally accepted methodology used by experts to project future asbestos-related health effects from an exposed labor force.[48] The Nicholson approach can be modified to reflect changes in the number of exposed workers by year by industry, exposure levels, and employment duration in specific cohorts, and it incorporates historical changes in hiring and exposure levels.

Nicholson collected workforce data from the Bureau of Labor Statistics, the Census, and labor unions in industries in which asbestos products were manufactured or used. Nicholson then estimated the number of workers exposed to asbestos beginning in 1935 through 1979 for eleven categories of asbestos-related industries and occupations. From his estimate of those with occupational exposure to asbestos, Nicholson projected the number of workers exposed and living in the years 1980 through 2045.

The exposed labor force estimate is used as an input to an epidemiological and economic model to estimate the incidence (of deaths) of asbestos-related mesothelioma and lung cancer over time. Users have made modifications to the 1982 Nicholson data and assumptions on the demographic characteristics of the exposed population and the formulas for calculating incidence of malignancies, as appropriate, to reflect more recent research and information on disease etiology and demographic data. Assumptions related to mortality have been updated to reflect the latest estimates with regard to longevity.

---

[47] *See* Nicholson WJ, Perkel, G. and Selikoff, I., "Occupational Exposure to Asbestos: Population at Risk and Projected Mortality," 1980-2030. *American Journal of Industrial Medicine* 3:259-311, 1982.

[48] The Nicholson model has been accepted in federal and state courts for these purposes.

In the Nicholson model, the number of exposed workers is further divided by duration of employment to capture turnover and the entry of new worker cohort populations. Nicholson's model was sufficiently sophisticated to account for short- and long-term workers.

Importantly and relevant to MSHA's modeling needs, the Nicholson model captured both the *duration* of exposure and the *level*(s) of exposure to estimate the cumulative dose to which a worker cohort was exposed. Workers were exposed to varying levels of airborne asbestos, depending on the industry and the trades in which they were employed. Accordingly, the level of asbestos to which workers were exposed is based on the estimated average annual fiber exposure in each of the 11 industries that Nicholson studied—not unlike MSHA's interest in different work locations.

In the Nicholson framework, industry-specific annual fiber concentration information is linked to the exposed population by its industry classification. The incidence model uses the annual fiber concentration information to compute cumulative and average fiber levels over the duration of exposure specific to each cohort population. The process of accumulating fiber level involves iteration through time, beginning with the first year of exposure for each particular cohort population and continuing until each particular cohort population is either no longer employed or is age 65, whichever comes first. At that point, exposures end for the living cohort population, but aging does not. At the end of each successive year in this aging process, the existing population is reduced by the general mortality rate from the Social Security Administration.

To estimate and project the number of living workers or retirees who are projected to develop mesothelioma due to asbestos exposure, current versions of the Nicholson model use the exposure-response model from the Occupational Safety and Health Administration (OSHA) which estimates mesothelioma mortality resulting from asbestos exposure. The OSHA mesothelioma exposure-response model is a model for absolute risk. Absolute risk is defined as the number of observed deaths per person-years at risk. The model defines the absolute risk as a function of time since first exposure (thereby capturing the age of the living cohort), exposure duration, and average fiber concentration.

To estimate and project the number of lung cancer deaths due to asbestos exposure, a dose-response model from OSHA is used to estimate lung cancer mortality resulting from asbestos exposure. The OSHA lung cancer dose-response model is a model for relative risk. Relative risk is defined as the ratio of the mortality rate of exposed persons to the mortality rate of equivalent non-exposed persons. In order to convert relative risk to a mortality rate, the relative risk is multiplied by the background mortality rate for lung cancer. The number of deaths resulting from asbestos exposure is the product of the adjusted mortality rate and the number of living exposed persons.

The Nicholson model is an appropriate framework for characterizing the time stream of expected benefits from the proposed rule. There is sufficient information about the size and age composition of the existing and new entrant work force. For this matter, work locations are analogous to the various industries examined by Nicholson, because they vary by exposure levels. Historical exposure can be accommodated by either beginning the model (and exposures) prior to the implementation of the proposed rule, or by setting initial levels of historical accumulated exposures for the cohort populations.

To illustrate why the current MSHA estimate of benefits likely is too large, Exponent collected data on the age distribution of miners in the primary states for underground mining.[49] These data are shown in Table 10.

[49] Surface-mining data are also available, but the employment information is complicated by the high proportion of contractors in the surface-mining segment. As a result, for this illustration, Exponent did not perform the same analysis for surface mining.

Table 10. Age cohorts of miners by state

State	Category	14-18	19-21	22-24	25-34	35-44	45-54	55-64	65-99
Alabama	New Hires	4	12	17	57	43	46	18	4
	Total Employment	9	68	156	754	734	1118	959	85
Colorado	New Hires	6	17	17	46	23	13	6	0
	Total Employment	5	89	168	702	531	603	380	25
Illinois	New Hires	3	15	21	74	48	38	22	2
	Total Employment	5	80	190	888	726	905	657	37
Indiana	New Hires	5	16	17	61	41	28	8	0
	Total Employment	5	82	201	861	899	892	428	21
Kentucky	New Hires	23	127	163	563	445	305	120	14
	Total Employment	24	555	1032	4188	4345	4702	2504	188
Ohio	New Hires	3	12	9	37	31	27	15	0
	Total Employment	5	66	113	494	537	775	686	79
Pennsylvania	New Hires	5	42	37	108	72	70	38	6
	Total Employment	11	152	295	1606	1249	2285	2036	204
Utah	New Hires	8	11	9	23	14	10	5	0
	Total Employment	20	66	97	475	322	479	287	22
Virginia	New Hires	4	21	24	85	79	62	26	9
	Total Employment	12	133	211	1149	1336	1856	1146	151
West Virginia	New Hires	13	112	123	561	450	349	166	12
	Total Employment	13	498	912	4685	4499	5394	3817	168
Totals	New Hires	73	383	435	1614	1247	947	423	45
	Total Employment	108	1787	3373	15802	15177	19008	12899	978
	% of New Hires	1.4%	7.4%	8.4%	31.2%	24.1%	18.3%	8.2%	0.9%
	% of Total Employment	0.2%	2.6%	4.9%	22.9%	22.0%	27.5%	18.7%	1.4%
	Total of New Hires				5166				
	Total of Total Employment				69130				
	Total of New Hires as a Percent of Total of Total Employment:				7%				

Notes:

1. Data from the U.S. Census Bureau – Local Employment Dynamics, available at: http://lehd.did.census.gov/led/datatools/qwiapp.html. Last viewed Apr. 9, 2011.

2. States selected based on underground mining production from Annual Coal Report 2009, U.S. Department of Energy, Tables 1 & 2, at p.12 – 17, *available at* http://www.eia.doe.gov/cneaf/coal/page/acr/acr.pdf

Using these data, I estimate that only 22.9 percent of current underground miners are in the age cohort that includes 28 year olds. This cohort is relevant to understand the living number of 73-year-olds who will have had 45 years of exposure by 2056 as defined by the MSHA hypothetical. Using current longevity 1980 cohort data, 74.2 percent of people that were born in 1980 and are alive in 2010 are expected to live to 73. Applying this to the 22.9 percent share of the current underground employment figures used by MSHA for the benefits estimate suggests that the living cohort population in 2056 with 45 years of exposure is at most 5614, or 17 percent of the MSHA assumed count.[50] Other cohorts either will not be 73 in 2056 or will not have 45 years of exposure.

While this illustration has considered only one worker cohort (25 to 34 year olds), this cohort satisfies MSHA's implicit risk reduction assumptions. The estimated risk reductions from the proposed rule for the other cohorts of the current work force will differ from the number of adverse health effects prevented that MSHA used in the PREA. MSHA's estimates of the prevented injuries are therefore unreliable and likely biased upward. The omitted cohorts either will be younger with the same amount of exposure (and therefore less risk) or older with less exposure, because exposure is expected to stop with retirement (and possibly less risk). Only approximately 1 percent of the current workforce is 65 or older. A reliable estimate of the prevented injuries, even assuming that the exposure-response models are correct, requires an analysis of the living cohorts characterized by such factors as year of first exposure, age, exposure levels, and duration.

1.5 Quantification of the Stream of Costs and Benefits Over Time

OMB guidance recommends that costs and benefits of a proposed rule be presented in schedules over time to illustrate the stream of impacts. Examining the timing of costs and benefits assists in understanding the near-term and distant consequences. The guidance also recommends that agencies address uncertainty directly by reflecting the full probability distribution of potential impacts through information such as the upper- and lower-bound estimates that help place the average measures in context.

---

[50] Following MSHA's statement about applying the risk estimates to the current number of coal miners, I assumed for this analysis that the 33,042 reflected the current count of miners. MSHA might have meant, however, that 33,042 was the number of the future living cohort population that is 73 in 2056 after 45 years of exposure. But that assumption would imply a population of current underground miners of more than 194,000, which is not consistent with MSHA's estimates of the number of underground miners employed.

MSHA's PREA did not include such schedules or uncertainty information. Exponent used the MSHA compliance cost information and the numbers reported on estimated benefits to construct the schedule of costs and benefits for underground miners. The scheduled values are shown in Table 11.

MSHA did not report the compliance costs over the 45-year period of exposure applied to the benefits analysis. MSHA did acknowledge that some compliance costs were annual, and therefore expected to occur every year that the proposed rule was in effect. MSHA also acknowledged that the expected operating life of the CPDM was five years. To construct the 45-year schedule, Exponent assumed that the costs for the CPDM units reoccurred every five years. Nonetheless, these assumptions and the use of a 45-year schedule made little difference in the estimated annualized cost of the proposed rule as measured by MSHA. The MSHA estimate is approximately $40 million[51], and the Exponent estimate is $38 million. The Exponent estimates, however, do not include adjustments for the omitted costs discussed and estimated in the sections above.

The methodology to estimate benefits per year differed substantially from the analysis of compliance costs. As discussed above, MSHA did not perform a year-by-year analysis of the avoided health injuries for the existing work force and new entrants over time. MSHA's analysis of benefits relies on particular assumptions about age (73 years) and the level of cumulative exposure after 45 years. Although MSHA's reported benefits are relevant only for those particular levels of age and accumulated exposure, MSHA divided the total benefits estimate by 45 years to derive a benefit per year. As MSHA noted, this measure should be regarded as an artificial estimate of the annual benefits:

> MSHA made the assumption that benefits begin immediately and that annual benefits equal lifetime benefits divided by 45 years. This assumption is equivalent

[51] *See* PREA at p. 195.

to assuming that the benefits begin to accrue in the first year after the provisions are put into effect, which MSHA admits is highly unrealistic.[52]

To explore the sensitivity of its unrealistic assumption, MSHA examined a particular scenario in which benefits would not be realized for 10 years, but nonetheless, would be larger in years 11 through 45.[53] The consequences of this treatment of annual benefits are a reduced net present value (NPV) and a reduced annualized benefit as shown in the table.

A more critical issue for the benefits estimation, however, is the inconsistency between MSHA's characterization of annual benefits and the exposure-response models. The MSHA approach essentially assumes that the total benefits "cover" a 45-year period uniformly. As I understand the exposure-response models used in the QRA, the benefits occur *after* a 45-year period of exposure. MSHA did not report a sensitivity study of the year-to-year avoided injuries by iterating the age and exposure assumptions even for a single hypothetical cohort. As a result, the direct information needed to test the reliability of the assumed pattern of avoided injuries has not been provided. The timing of the benefits values entered in the table above should be understood with this concern in mind. Annual costs are immediately and realistically incurred for the proposed rule, while the annual benefits, at least based on the analysis reported in the PREA, are manipulations of the benefits that might be realized after 45 years.

The Exponent benefits are based on the MSHA assumptions about benefit patterns and the adjustments for the age cohort and longevity discussed above. Importantly, the consequences of these adjustments are to reduce the NPVs and the annualized benefits substantially. The NPV and annualized costs of the proposed rule now exceed the values for the benefits. The Exponent adjustments illustrate the potential importance of MSHA's assumptions regarding the populations at risk. The reversal of the cost/benefit results demonstrates that reliable estimates of the regulatory consequences of the proposed rule must be based on realistic assumptions about the anticipated impacts from reduced exposures to the existing work force and new entrants. This requirement has not been accomplished by the current PREA.

---

52 *See* PREA at p. 23.

53 *Ibid.*

Table 11. Schedule of costs and benefits (in millions of 2009$)

Year	Annual Costs	Estimated Benefits Per Year: MSHA Estimate		Estimated Benefits Per Year: Exponent Adjustments: Cohort Share & Longevity[1]	
1	$79	$158		$27	
2	$37	$158		$27	
3	$29	$158		$27	
4	$29	$158		$27	
5	$29	$158		$27	
6	$52	$158		$27	
7	$39	$158		$27	
8	$29	$158		$27	
9	$29	$158		$27	
10	$29	$158		$27	
11	$52	$158	$204	$27	$35
12	$39	$158	$204	$27	$35
13	$29	$158	$204	$27	$35
14	$29	$158	$204	$27	$35
15	$29	$158	$204	$27	$35
16	$52	$158	$204	$27	$35
17	$39	$158	$204	$27	$35
18	$29	$158	$204	$27	$35
19	$29	$158	$204	$27	$35
20	$29	$158	$204	$27	$35
21	$52	$158	$204	$27	$35
22	$39	$158	$204	$27	$35
23	$29	$158	$204	$27	$35
24	$29	$158	$204	$27	$35
25	$29	$158	$204	$27	$35
26	$52	$158	$204	$27	$35
27	$39	$158	$204	$27	$35
28	$29	$158	$204	$27	$35
29	$29	$158	$204	$27	$35
30	$29	$158	$204	$27	$35
31	$52	$158	$204	$27	$35
32	$39	$158	$204	$27	$35
33	$29	$158	$204	$27	$35
34	$29	$158	$204	$27	$35
35	$29	$158	$204	$27	$35
36	$52	$158	$204	$27	$35
37	$39	$158	$204	$27	$35
38	$29	$158	$204	$27	$35
39	$29	$158	$204	$27	$35
40	$29	$158	$204	$27	$35
41	$52	$158	$204	$27	$35
42	$39	$158	$204	$27	$35
43	$29	$158	$204	$27	$35
44	$29	$158	$204	$27	$35
45	$29	$158	$204	$27	$35
Total	**$1,614**	**$7,123**	**$7,123**	**$1,210**	**$1,210**
NPV[2]	**$515**	**$2,154**	**$1,340**	**$366**	**$228**
Annualized Value[3]	**$38**	**$158**	**$98**	**$27**	**$17**

Notes:

1. Adjusted by 22.9% for cohort share and 74.2% for longevity.
2. "NPV" stands for Net Present Value. This is calculated by applying a discount rate to each year (calculated as discount rate = $1/(1+0.07)^n$ where n is the year) and summing the resulting values.
3. Annualized Values is calculated as Total * 0.0735. This annualization factor of 0.0735 is based on a 45 year time-frame and is calculated as $(0.07*(1.07^{45}))/((1.07^{45})-1) = 0.0735$

2 Conclusions

Based on my review of the PREA and the analyses presented in this report, I have reached the following conclusions:

- MSHA's cost of compliance analysis is inconsistent with critical industry facts.
- Using *only* the omitted costs in this analysis indicated that the estimate is likely many times the MSHA estimate of total industry costs.
- MSHA's analysis of benefits is based on an unrealistic hypothetical and likely overestimates the benefits of the proposed rule, even assuming that the exposure-response models are valid.
- MSHA suggests in the PREA that it cannot estimate benefits properly, but a proper framework is available in the literature.
- When reasonable adjustments to benefits are made based on realistic assumptions regarding the exposed work force in underground mining, the NPV and annualized costs of the proposed rule *exceed* the value of the benefits.
- The PREA does not contain an accurate or complete regulatory analysis of cost and benefits under the proposed rule, nor any analysis of alternative regulatory approaches.

3 References

Email from Bruce Watzman, NMA, to Michael Meighen, Murray Energy Corporation, and Dr. Robin Cantor, Exponent (Jan. 31, 2011 11:05am) (on file with author).

Environmental Protection Agency, "Guidelines for Preparing Economic Analyses," EPA Report number 240-R-10-001 (Dec. 2010).

Excel File "DUST_Data_(2001_thru_2010)_(2-11-11).xls".

Federal Register, "Department of Labor, Mine Safety and Health Administration, 30 CFR Parts 70, 71, 72, et al., Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors; Proposed Rule," *available at* http://www.msha.gov/REGS/FEDREG/PROPOSED/2010Prop/2010-25249.pdf (last visited Apr. 18, 2011).

Federal Register, "Department of Labor, Mine Safety and Health Administration, 30 CFR Parts 70, 71, 72, et al., Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors; Request for Comments" *available at* http://www.msha.gov/REGS/FEDREG/PROPOSED/2011PROP/2011-5127.PDF (last visited Apr. 18, 2011).

Kogut, Jon, "Quantitative Risk Assessment in Support of Proposed Respirable Coal Mine Dust Rule," Delivered to MSHA under Contract DOLJ094R22516 (Sep. 2010).

Mining Safety and Health Administration, "Transcription of Proceedings in the Matter of: Lowering Miners' Exposure to Respirable Coal Mine Dust, Including Continuous Personal Dust Monitors; Proposed Rule." Transcript of public hearing in Arlington, VA (Feb. 15, 2011).

Murray Energy Corporation, "CPDM requirements under the proposed rule," Word document (rcd. by Exponent Jan. 10, 2011).

Murray Energy Corporation, "Statistics – Various," Excel document (rcd. by Exponent Jan. 31, 2011).

Nicholson WJ, Perkel, G. and Selikoff, I., "Occupational Exposure to Asbestos: Population at Risk and Projected Mortality," 1980-2030. *American Journal of Industrial Medicine* 3:259-311, 1982.

Office of Budget Management, Circular No. A-4, "Regulatory Analysis" (Sep. 17, 2003).

Pennsylvania Coal Association, "Testimony of George Ellis, President, Pennsylvania Coal Association, Proposed Rule Making on Respirable Coal Mine Dust, February 8, 2011, "Word document (Feb. 8, 2011).

Thermo Fisher Scientific, "2011 PDM3600 CPDM Collaborative Purchase Program," PowerPoint slides, (2011).

Torma-Krajewski, Janet, "Written Comments for Submittal," Draft written comments submitted to MSHA on the ergonomics of the proposed rule (Apr. 19, 2011).

U.S. Census Bureau, "Local Employment Dynamics," *available at* http://lehd.did.census.gov/led/datatools/qwiapp.html (last viewed Apr. 9, 2011).

U.S. Department of Energy, "Annual Coal Report 2009," Report number DOE/EIA-0584 (Feb. 3, 2011).

U.S. Department of Labor, Mine Safety and Health Administration, Office of Standards, Regulations, and Variances, "Preliminary Regulatory Economic Analysis For Lowering Miners' Exposure to Respirable Coal Mine Dust Including Continuous Personal Dust Monitors Proposed Rule," Document Number RIN 1219-AB64 (Sep. 2010).

U.S. Department of Labor, Mine Safety and Health Administration, Office of Standards, Regulations, and Variances, "Preliminary Regulatory Economic Analysis For The Proposed Rule Concerning Determination of Concentration of Respirable Coal Mine Dust and The Proposed Rule for Verification of underground Coal Mine Operators' Dust Control Plans and Compliance Sampling for Respirable Dust," Document Numbers RIN-1219-AB18 & RIN-1219-AB14 (Feb. 2003).

Watson, Mark and Health Lovell, "National Mining Association, Analysis of MSHA Coal Dust Sampling Data Base & The Impact Of The MSHA Proposed Rule," PowerPoint slides presented to MSHA panel at Arlington, VA public hearing on the proposed rule (Feb. 15, 2011).

Attachment A

Curriculum Vitae for
Dr. Robin Cantor

Robin A. Cantor, Ph.D.
Principal

Professional Profile

Dr. Robin Ann Cantor is a Principal in Exponent's Alexandria, VA office. She specializes in applied economics, environmental and energy economics, statistics, risk management, and insurance claims analysis. Prior to joining Exponent, she led the Liability Estimation practice at Navigant Consulting and assisted companies and financial institutions with analysis to better understand asbestos and other product liability exposures. Other positions she has held include: Principal and Managing Director of the Environmental and Insurance Claims Practice at LECG, LLC, Program Director for Decision, Risk, and Management Sciences, a research program of the National Science Foundation, and senior research appointments at Oak Ridge National Laboratory. Dr. Cantor has a faculty appointment in the Graduate Part-time Program in Engineering of the Johns Hopkins University. She was the President of the Society for Risk Analysis in 2002, and from 2001-2003, she served as an appointed member of the Research Strategies Advisory Committee of the US Environmental Protection Agency's Science Advisory Board. She is a member of the Executive Committee for the Women's Council on Energy and the Environment. Dr. Cantor's testimonial experience includes analysis of economic damages, product liability estimation in bankruptcy matters and insurance disputes, statistical analysis of asbestos settlements, analysis of premises and product claims, cost contribution allocation in Superfund disputes, analysis of derailment risks, reliability of statistical models and estimation methods, and economic analysis of class certification issues. She has prepared expert reports that address economic issues in antitrust, commercial practices and contracts, intellectual property, employment discrimination, false advertising, regulation, and other areas of product and market analysis. Dr. Cantor has submitted analysis, testimony and affidavits in federal arbitration, regulatory and Congressional proceedings, and state and federal courts. Dr. Cantor's publications include refereed journal articles, book chapters, expert reports, reports for federal sponsors, and a book on economic exchange under alternative institutional and resource conditions.

Academic Credentials and Professional Honors

Ph.D., Economics, Duke University, 1985
B.S., Mathematics, Indiana University of Pennsylvania, 1978

Fellow, Society for Risk Analysis, 2002
President, Society for Risk Analysis, 2002
YWCA Tribute to Women Award for Business and Industry, 1990

Society for Risk Analysis Presidential Recognition Award, 2008; Society for Risk Analysis Outstanding Service Award, 1999; NSF Director's Award for Superior Accomplishment, 1996; NSF Special Act Award, 1995; NSF Director's Award for Program Officer Excellence, 1994;

Oak Ridge National Laboratory Significant R&D Accomplishment Award, 1993; Martin Marietta Special Achievement Award, 1990; Martin Marietta Special Achievement Award, 1989; Martin Marietta Energy Systems Significant Event Award, 1988; C.B. Hoover Scholar, 1980–1981; Mellon Fellowship, 1978–1981

Publications

Cantor RA (ed.). Product Liability. ABA Publishing: Chicago IL, 2011.

Cantor RA, Lyman M, Reiss R. Asbestos claims and litigation. In: Cantor RA (ed.). Product Liability. ABA Publishing: Chicago IL, 2011: 125-145.

Review Committee (Cantor RA – member). Review of the Department of Homeland Security's approach to risk analysis. National Research Council, The National Academies Press: Washington, D.C., 2010.

Cantor RA, Gunaseelan P, Vopelius J, Bandza A. Creating and financing the next-generation carbon offset project: An application to carbon capture and storage. In: Energy and Environmental Project Finance Law and Taxation: New Investment Techniques. Kramer AS, Fusaro PC (eds), Oxford University Press, 2010:15–38.

Cantor RA, Lyman M, Reiss R. Asbestos claims and litigation. John Liner Rev 2009; 23(2): 28-38.

Cantor RA, Hlavin A, Katofsky R, McDonald C. Current perspectives on trading environmental attributes. In: Energy and Environmental Trading: U.S. Law and Taxation. Kramer A, Fusaro P (eds), Cameron May, 2008; 183–235.

Cantor RA. Enterprise risk management perspectives on risk governance. In: Global Risk Governance: Concept and Practice using the IRGC Framework. Renn O, Walker K (eds), Springer Press, 2008.

Nieberding J, Cantor RA. Price dispersion and class certification in antitrust cases: An economic analysis. J Legal Econ 2007; 14(2):61–84.

Bunting C, Renn O, Florin M-V, Cantor RA. Introduction to the IRGC risk governance framework. John Liner Rev 2007; 21(2):7–26.

Cantor RA, Lyman M. Asbestos and state tort reforms. John Liner Rev 2007; 20(4):39–45.

Cantor RA, Cook M, Lyman M. Is the end in sight? Global Reinsurance 2006; September, 45–46.

Cantor RA, Cook M, Lyman M. After the FAIR Act. Run Off Business 2006; 17:34–36.

Cantor RA, Cook M. A chink in the FAIR Act. Global Reinsurance 2006; April, 9.

Morgan MG, Cantor RA, Clark B, Fisher A, Jacoby J, Janetos T, Kinzing, Melillo J, Street R, Wilbanks T. Learning from the U.S. national assessment of climate change impacts. Environ Sci Technol 2005; October.

Nieberding J, Cantor RA. Price dispersion, the "Bogosian Short Cut," and class certification in antitrust cases. ABA Antitrust Law, Economics Committee Newsletter 2004; 4(1):5–9. Also reprinted in Texas Business Litigation 2005; 23–25.

Zimmerman R, Cantor RA. State of the art and new directions in risk assessment and risk management: Fundamental issues of measurement and management. In: Risk Analysis and Society: An Interdisciplinary Characterization of the Field. McDaniels TL, Small MJ (eds), Cambridge University Press, 2004.

Cantor RA. Introduction to the 2001 best paper special issue. Risk Anal 2003; 23(6):1209–1210.

Adams GD, Cantor RA. Risk, stigma, and property values: What are people afraid of? pp. 175–186. In: Risk, Media and Stigma. Flynn J, Kunreuther H, Slovic P (eds), pp. 175–186, Earthscan Publications, Ltd., 2001.

Cantor RA, Rayner S, Henry S. Markets, distribution & exchange after societal cataclysm, Books for Business, December 2000.

Cantor RA. Discussion paper on net environmental benefits assessment for restoration projects after oil spills, or some reflections on the decision process. pp. 145–152. In: Restoration of Lost Human Uses of the Environment. Cecil G (ed), SETAC Press, 1999.

Cantor RA, Yohe G. Economic analysis. pp. 1–93. In: Human Choice and Climate Change: An International Assessment, Volume 3: Tools for Policy Analysis. Rayner S, Malone EL (eds), Battelle Press, 1998.

Cantor RA (contributor), Jaeger CC, Renn O, Rosa EA, Webler T, McDonell G, Sergen G (eds.) Decision analysis. pp. 141–2216. In: Human Choice and Climate Change: An International Social Science Assessment State of the Art Report, Volume 3. Rayner S, Malone EL (eds), Battelle Press, 1998.

Cantor RA. Rethinking risk management in the federal government. Ann Am Acad Political Social Sci 1996; 545:135–143.

Cantor RA. Estimating externalities of coal fuel cycles, Lee R (ed.), Report 3, Utility Data Institute, McGraw-Hill, Washington, DC, 1994.

Cantor RA, Rayner S. Changing perceptions of vulnerability. In: Industrial Ecology and Global Change. Socolow R, Andrews C, Berkhout F, Thomas V (eds), Cambridge University Press, 1994.

Cantor RA, Schoepfle M. Risk, rationality, and community: Psychology, ethnography, and transactions in the risk management process. The Environmental Professional 1993; 15:293–303.

Cantor RA, Henry S, Rayner S. Making markets: An interdisciplinary perspective on economic exchange, Greenwood Press, Delaware, 1992.

Fulkerson W, Jones J, Delene J, Perry AM, Cantor RA. The potential role of nuclear power in controlling CO_2 emissions. In: Limiting the Greenhouse Effect: Options for Controlling Atmospheric CO_2 Accumulation. Pearman GI (ed), John Wiley and Sons, 1992.

Cantor RA, Schoepfle M, Szarleta E. Sources and consequences of hypothetical bias in economic analysis of risk behavior. In: The Analysis, Communication, and Perception of Risk. Garrick BJ, Gekler WC (eds), Plenum Press, New York, 1991.

Cantor RA. Applying construction lessons to decommissioning estimates. Energy J 1991; 12:105–117.

Cantor RA, Rizy C. Biomass energy: Exploring the risks of commercialization in the United States of America. Bioresource Technol 1991; 35(1):1–13.

Cantor RA, Krupnick A, Rizy C. Beyond the market: Recent regulatory responses to the externalities of energy production. pp. 51–61. Proceedings, 1991 Conference of the National Association of Environmental Professionals, 1991.

Cantor RA, Rayner S. Thinking the unthinkable: Preparing for global disaster. In: New Risk: Issues in Management. Ricci P (ed), Plenum Press, New York, 1990.

Cantor RA, Jones D, Lieby P, Rayner S. Policies to encourage private sector responses to potential climate change. In: Energy Markets in the 1990s and Beyond. Finizza A, Weyant JP (eds), IAEE, Washington, DC, 1989.

Cantor RA, Hewlett J. The economics of nuclear power: Some new evidence on learning, economies of scale, and cost estimation. Resources Energy 1988; 10:315–335.

Rayner S, Cantor RA. Quand le risque acceptable est-it socialement justifie. In : La Societé Vulnerable, Fabiani J-L, Theys J (eds), Presses De L'École Normale Supérieure, Paris, 1987.

Cantor RA, Rayner S, Braid RB. The role of liability preferences in societal technology choices: Results of a pilot study. In: Risk Assessment and Management. Lave L (ed), Plenum Press, New York, 1987.

Rayner S, Cantor RA. How fair is safe enough? The cultural approach to societal technology choice. Risk Anal 1987; 7(1):3–9.

Cantor RA, Rayner S. The fairness hypothesis and managing the risks of societal technology choices. ASME, paper 86-WA/TS-5, December 1986.

Cantor RA. Regulatory trends and practices related to nuclear reactor decommissioning. In: The Energy Industries in Transition 1985–2000. Weyant JP, Sheffield DB (eds), IAEE, Washington, DC, 1984.

Other Publications

Cantor RA, Patrick B. Commercialization of nanotechnology: Enterprise risk management issues. Background Paper presented to the ABA Section of Environment, Energy, and Resources Nanotechnology Panel, 36th Annual Conference on Environmental Law, Keystone, CO, March 8–11, 2007.

Cantor RA, Zimmerman R. First World Congress on Risk "Risk and Governance" conference highlights. Risk Newsletter 2003; 23(4):1–10.

Cantor RA. Risk analysis in an interconnected world. RISK Newsletter 2001; 21(3):1–3.

Cantor RA, Zimmerman R. Risk and governance: An international symposium. RISK Newsletter 2001; 21(1):20–21.

Cantor RA. Book review of *Public Reactions to Nuclear Waste* by Riley E. Dunlap, Michael E. Kraft, and Eugene A. Rosa. Science 1994; 266:145.

Cantor RA. News from Washington. Human Dimensions Quarterly 1994; 1(2):20–21.

Cantor RA. Book review of *The Risk Professionals* by Thomas M. Dietz and Robert W. Rycroft. Environmental Professional 1989; 11(4):458–459.

Cantor RA. Decommissioning: The Next chapter in the nuclear saga. FORUM 1988; 3(3):105–106.

Technical Manuscripts

Menzie C, Cantor R, Boehm P, Bailey JR. An approach to business vulnerability and risk assessments related to climate change. SPE Paper Number SPE-127083-PP, November, 2009.

Analysis of the Estimated Production Cost Savings From Replacing the Dollar Note with the Dollar Coin. Final report of analysis submitted to Congressional Record, June 12, 2000 (with Jessica B. Horewitz and Robert N. Yerman).

Rebuttal Verified Statement with Gordon C. Rausser for CSX Corporation and CSX Transportation, Inc., Norfolk Southern Corp., and Norfolk Southern Railway Co., Control and Operating Leases/Agreements, Conrail Inc. and Consolidated Rail Corp., Railroad Control Application, Applicants' Rebuttal Vol. 2B of 3, December, 1997.

Community Preferences and Superfund Responsibilities. Prepared for the USEPA under Interagency Agreement 1824-B067-A1 with Oak Ridge National Laboratory, August 1993.

The U.S.-EC Fuel Cycle Study: Background Document to the Approach and Issues. Oak Ridge National Laboratory, ORNL/TM-2500, November, 1992 (with L. W. Barnthouse, D. Burtraw (Resources for the Future), G. F. Cada, C. E. Easterly, A. M. Freeman (Bowdoin College), W. Harrington (Resources for the Future), T.D. Jones, R. L. Kroodsma, A. J. Krupnick (Resources for the Future), R. Lee, H. Smith (DOE), A. Schaffhauser, and R. S. Turner).

What are the Problems of Equity and Legitimacy Facing a Management Strategy for the Global Commons? Managing the Global Commons: Decision Making and Conflict Resolution in Response to Climate Change, Oak Ridge National Laboratory, ORNL/TM-11619, July, 1990 (with Roger Kasperson in Steve Rayner, Wolfgang Naegeli, and Patricia Lund).

Markets, Distribution, and Exchange after Societal Cataclysm, Oak Ridge National Laboratory, ORNL-6384, November 1989 (with S. Rayner and S. Henry).

Information. Chapter 5 of A Compendium of Options for Government Policy to Encourage Private Sector Responses to Potential Climate Change, DOE/EH-0102, Report to Congress, October, 1989 (with G. G. Stevenson and P. J. Sullivan).

Agriculture and Forestry. Chapter 10 of A Compendium of Options for Government Policy to Encourage Private Sector Responses to Potential Climate Change, DOE/EH-0102, Report to Congress, October, 1989 (with W. Naegeli and A. F. Turhollow, Jr.).

Evaluation of Implementation, Enforcement and Compliance Issues of the Bonneville Model Conservation Standards Program, Vol. I and II, ORNL/CON-263, July 1989 (with Steve Cohn).

Gas Furnace Purchases: A Study of Consumer Decision Making and Conservation Investments. ORNL/TM-10727, October 1988 (with David Trumble).

An Analysis of Nuclear Power Plant Construction Costs. DOE/EIA-0485, 1986 (with J. G. Hewlett and C. G. Rizy).

Nuclear Reactor Decommissioning: A Review of the Regulatory Environments. ORNL/TM-9638, 1986.

Nuclear Power Options Viability Study, Vol. I, Executive Summary, ORNL/TM-9780/1, 1986 (with D. B. Trauger et al.).

Nuclear Power Options Viability Study, Vol III, Nuclear Discipline Topics. ORNL/TM-9780/3, 1986 (with D. B. Trauger et al.).

Clinch River Breeder Reactor: An Assessment of Need for Power and Regulatory Issues, ORNL/TM-8892, September 1983 (with D. M. Hamblin et al.).

Selected Presentations

Cantor RA. Evaluating vulnerabilities and identifying emerging risks. Invited presentation, The Conference Board EHS Legal Counsel Meeting, Houston TX, January 15–16, 2009.

Cantor RA. Using exposure science to ascertain asbestos liabilities. Invited CLE presentation, Business Valuation Resources, LLC Teleconference, November 18, 2008.

Cantor RA. Weather and temperature: Emerging health issues for US companies. REBEX 2008, Wheeling IL, October 23–24, 2008.

Cantor RA. Asbestos risk transfers: Unlocking value by walling off asbestos liabilities. Invited CLE session at Willkie Farr & Gallagher, New York, NY, June 4, 2008.

Cantor RA. The future of asbestos—New techniques for unlocking value by selling liabilities to investors. Mealey's™ Teleconference, March 25, 2008.

Cantor RA. Update on other U.S. long-tailed product liabilities. Invited presentation, 4th International Asbestos Claims & Liabilities Conference: The Practical Guide to Litigating, Settling and Managing Asbestos Claims, London, January 30–31, 2008.

Cantor RA. Tax or cap: What are the real differences for carbon policy in the US? Invited session and presentation, McDermott Will & Emery 10th Annual Energy Conference, Washington DC, October 9–10, 2007.

Cantor RA. Managing nanotechnology's life cycle risks responsibly. Invited ALI-ABA teleconference, June 27, 2007.

Cantor RA. Carbon emissions—Planning for the change. Invited teleconference, Environmental Law Network, June 15, 2007.

Cantor RA. Liability estimation and the historical future. Invited presentation, Mealey's™ Asbestos Bankruptcy Conference, Chicago, IL, June 7–8, 2007.

Cantor RA. Renewables and the value proposition for carbon credits. Invited presentation, McDermott Will & Emery 9th Annual Energy Conference, Washington DC, October 19–20, 2006.

Cantor RA. The ABCs of the value proposition for carbon credits. Invited presentation, the Environmental Trading Congress, New York, NY, July 24–25, 2006.

Cantor RA, Lyman M. Liability estimation in U.S. bankruptcy cases. London Underwriting Centre, London, UK, January 10, 2006.

Cantor RA, Lyman M. The status of the FAIR Act. London Underwriting Centre, London, UK, January 10, 2006.

Cantor RA. Economic appraisal of ecological assets. Invited presentation, U.S. Environmental Protection Agency Science Advisory Board "Science and the Human Side of Environmental Protection" Series, Washington, DC, July 6, 2002.

Cantor RA. Scientists and Homeland Security—The relevance of risk analysis. Invited presentation, Council of Scientific Society Presidents, Washington, DC, May 2002.

Cantor RA. NRD rules and economics. Invited presentation, Environmental and Admiralty Law Committees of the Association of the Bar of the City of New York, December 7, 2000.

Cantor RA. Revealed preferences and environmental risks: Lessons learned from two policy debates. Annual Meetings of the Society For Risk Analysis, Phoenix, AZ, December 8, 1998.

Cantor RA. Valuing environmental impacts: Lessons learned from the natural resource damage debate. Invited Paper, Society of Environmental Toxicology and Chemistry, 19th Annual Meeting, November 19, 1998.

Cantor RA. How will climate change affect economics and politics? Invited panel speaker, Policy and Politics of Climate Change, ABA Section of Natural Resources, Energy, and Environmental Law Fall Meeting, October 8, 1998.

Cantor RA. Natural resource damage rules: A search for the path of least resistance in value disputes? George Washington University Seminar Series on Environmental Values and Strategies, September 1997.

Cantor RA. Rethinking the science of risk management: Changing paradigms of the process and function. Operations and Information Management Department Workshop, Wharton School of the University of Pennsylvania, November 1995.

Cantor RA, Arkes H. Interdisciplinary perspectives on experimental methods. 1995 Meetings of the American Economic Association, January 1995.

Cantor RA. Risk management: Four different views. Invited presentation, The Conservation of Great Plains Ecosystems Symposium, April 1993.

Cantor RA. Human dimensions of global change: A white paper on the USGCRP research programs. National Academy of Sciences Board on Global Change, November 1993.

Ex™

Cantor RA, Rayner S. Changing perceptions of vulnerability. Invited paper, NCAR/UCAR Summer Institute on Industrial Ecology and Global Change, July 17–31, 1992.

Cantor RA. Should economic considerations limit the conservatism of risk assessment? Invited paper, Workshop of the International Society of Regulatory Toxicology and Pharmacology on Risk Assessment and OMB's Report on its Application in Regulatory Agencies, Washington, DC, June 11, 1991.

Cantor RA. Beyond the market: Recent regulatory responses to the externalities of energy production. Annual Meetings of the National Association of Environmental Professionals, Baltimore, MD, April 30, 1991.

Cantor RA. Understanding community preferences at Superfund sites. National Meeting of EPA Community Relations Coordinators, Chicago, IL, April 4–6, 1990.

Cantor RA. Methodological myths and modeling markets: A common framework for analyzing exchange. Second Annual International Conference on Socio-Economics, Washington, DC, March 1990.

Cantor RA, Schoepfle GM, Szarleta EJ. Sources and consequences of hypothetical bias in economic analyses of risk behavior. 1989 Meetings of Society for Risk Analysis, October 1989.

Cantor RA, Jones D, Lieby P, Rayner S. Policies to encourage private sector responses to potential climate change. 1989 Meetings of International Association of Energy Economists, October 1989.

Cantor RA, Szarleta EJ. The experimental approach in public policy analysis: precepts and possibilities. Public Choice Society and Economic Science Association Annual Meetings, Orlando, FL, March 17–19, 1989.

Cantor RA, Rayner S. Global disaster management: Developing principles for research. 1988 Meetings of the Association for Public Policy Analysis and Management, October 1988.

Cantor RA. Implementation and enforcement issues from early adopter experience. Regional Evaluation Network, Northwest Power Planning Council, Portland, OR, June 1988.

Cantor RA. Using information from toxic-tort litigation to value the health and safety consequences of regulatory decisions. Public Policy Workshop, the Department of Economics and Waste Management Research and Education Institute, University of Tennessee, Knoxville, TN, February 1988.

Cantor RA, Bishop R, Jr. Valuing safety and health effects in regulatory decisions: A revealed-preference approach. 1987 Annual Meeting of the Society for Risk Analysis, November 3, 1987.

Cantor RA. Government intervention and technology prices: The CANDU example. Invited paper, WATTEC Conference, Knoxville, TN, February 19, 1987.

Cantor RA. Fairness hypothesis and managing the risks of societal technology choices. 1986 Winter Annual Meeting of the American Society of Mechanical Engineers, Anaheim, CA, December 10–12, 1986.

Cantor RA. A retrospective analysis of technological risk: The case of nuclear power. Invited paper, Center of Resource and Environmental Policy Workshop Series, Vanderbilt University, Nashville, TN, December 4, 1986.

Cantor RA, Petrich C, Mercier J-R. Evaluation of a large-scale charcoal project in Madagascar: Attacking the deforestation problem from the supply side. 1986 IAEE North American Conference, Cambridge, MA, November 19–21, 1986.

Cantor RA, Rayner S. Tools for the job: Choosing appropriate strategies for risk management. 1986 Annual Meeting of the Society for Risk Analysis, Boston, MA, November 9–12, 1986.

Cantor RA, Rayner S. Thinking the unthinkable: Preparing for global disaster. 1986 Annual Meeting of the Society for Risk Analysis, Boston, MA, November 9–12, 1986.

Cantor RA, Rayner S, Braid B. The Role of liability preferences in societal technology choices: Results of a pilot study. 1985 Annual Meetings of Society for Risk Analysis, Washington, DC, October 8, 1985.

Conference Participation

Invited panelist for "An Integrated Risk Framework for Gigawatt-Scale Deployments of Renewable Energy: The Wind Energy Case Study," 2009 Annual Meeting for the Society for Risk Analysis, Baltimore, MD, December 9, 2009.

Invited session organizer and panelist for "Global Warming and Greenhouse Gas Controls: What do they mean for you?" 2008 Annual Meeting of the National Association of Publicly Traded Partnerships, Washington DC, June 26, 2008.

Co-chair, "Second World Congress on Risk," Guadalajara, Mexico, June 2008.

Invited panelist for "Climate Litigation: The Next Asbestos or the Next Y2K?" ABA Section of Litigation Annual Conference, Washington DC, April 17, 2008.

Invited panelist for "Business of Mitigation: Carbon Offsets and Trading," Oxford University Capstone Conference, Oxford, UK, September 10, 2007.

Panelist for "Issues Concerning Implementation," at the Public Forum on OMB's Proposed Risk Assessment Bulletin: Implications for Practice Inside and Outside Government, sponsored by Society for Risk Analysis, Society of Environmental Toxicology and Chemistry in North

America, Society of Toxicology, and International Society of Regulatory Toxicology and Pharmacology.

Session Chair, "Challenges Facing Industrial Countries," with key-note speeches by Philippe Busquin, EU Commissioner for Research, and Dr. John Graham, Administrator of the US Office of Information and Regulatory Affairs, Inaugural Conference of the International Risk Governance Council, Geneva, Switzerland, June 29, 2004.

Co-Chair, "First World Congress on Risk," Brussels, Belgium, June 2003.

Chair of the Organizing Committee, 2001 Annual Meetings for the Society for Risk Analysis.

Member of the Organizing Committee, Risk and Governance Symposium, Society for Risk Analysis, June 2000.

Organizing Committee Member for the 1996, 1997, 1998, and 2002 Annual Meetings of the Society for Risk Analysis.

Panelist for Net Environmental Benefits Assessment for Restoration Projects after Oil Spills, Conference on Restoration for Lost Human Uses of the Environment, Washington, DC, May 1997.

Session Organizer and Chair for Cost Benefit Analysis and Risk Assessment at the 1996 Annual Meeting of the Society for Risk Analysis.

Panelist for Challenges in Risk Assessment and Risk Management sponsored by The Annenberg Public Policy Center of the University of Pennsylvania at the National Press Club, Washington, DC, May 16, 1996.

Panelist for Media and Risk in a Democracy: Who Decides What Hazards Are Acceptable? At the 1995 Annual convention of the Association for Education in Journalism and Mass Communication.

Session Organizer and Co-Chair for Experimental Methods: Insights from Economics and Psychology at the 1995 Meetings of the American Economic Association.

U.S. Organizer for the Third Japan-U.S. Workshop on Global Change Modeling and Assessment: Improving Methodologies and Strategies, Hawaii, October 1994.

Cluster Organizer for three sessions on Competitiveness at the Fall Meeting of the Operations Research Society of America/The Institute of Management Sciences, 1994.

Roundtable Panelist for Risk Communication Research: Defining Practitioner Needs at the 1994 Meetings of the Society for Risk Analysis.

Workshop Organizer for Organizational Transformation and Quality Systems, National Science Foundation, 1993.

Session Chair and Organizer for the NSF/Private Sector Research Initiative Projects at the 1992 Meetings of the Society for Risk Analysis.

Roundtable Panelist for the EPA Session on Risk Communication at the 1990 Meetings of the Society for Risk Analysis.

Session Chair and Organizer for the Computer Assisted Market Institutions Session at the Advanced Computing for the Social Sciences Conference, April 1990.

Discussant for the Issues in LDC Public Finance Session at the 1988 Meetings of the American Economic Association.

Session Chair and Organizer for Social Science Innovations in Risk-Analysis Methods, Special Session at the 1988 Meetings of the Society for Risk Analysis.

Prior Experience

Managing Director, Navigant, 2004–2008
Lecturer, Graduate Program, Johns Hopkins University, Engineering and Applied Science Programs for Professionals, Program in Environmental Engineering, Science and Management, 1996–present
Principal and Managing Director, LECG, 1999–2004
Senior Managing Economist, LECG, 1999
Managing Economist, LECG, 1996–1998
Member, U.S. Environmental Protection Agency, Science Advisory Board, Research Strategies Advisory Committee, 2001–2003
Program Director, Decision, Risk, and Management Science, National Science Foundation, 1992–1996
Coordinator, NSF Human Dimensions of Global Change, 1992–1996
Project Manager, Oak Ridge National Laboratory, 1990–1991
Technical Assistant to the Associate Director, Advanced Energy Systems, Oak Ridge National Laboratory, 1989–1990
Group Leader, Social Choice and Risk Analysis Group, Energy and Economic Analysis Section, Oak Ridge National Laboratory, June 1987–1989
Research Staff, Energy and Economic Analysis Section, Oak Ridge National Laboratory, Oak Ridge National Laboratory, October 1982–1987
Consultant, Indonesian Energy Project, Harvard Institute For International Development, July 1987
Visiting instructor, North Carolina Central University, Spring 1982

Advisory and Other Appointments

- National Research Council Committee to Review the Department of Homeland Security's Approach to Risk Analysis, November, 2008–present
- Executive Committee, Women's Council on Energy and the Environment, 2006–present
- Board Member, Women's Council on Energy and the Environment, 2004–2006
- Member, Advisory Group for the Joint Global Change Research Institute, a collaboration between Pacific Northwest National Laboratory and the University of Maryland, 2004–2008
- Member, Planning Committee for a study to evaluate the U.S. National Assessment of the Potential Consequences of Climate Variability and Change, coordinated through Carnegie Mellon University, 2004
- Neutral technical panelist working with Arbitrator Anthony Sinicropi on negotiation issues related to the pilots' compensation contract. Retained by US Airways and the Air Line Pilots Association (ALPA), 2001 and 2002
- Advisory Board Member, Johns Hopkins University Graduate Part-Time Program in Environmental Engineering and Science, 2000–2004
- Planning Committee Member, Carnegie Council on Ethics and International Affairs Long Term Study of Culture, Social Welfare, and Environmental Values in the U.S., China, India, and Japan, initiated January 1997
- Vice-Chair, U.S. Global Change Research Program working group on Assessment Tools and Policy Sciences, 1994–1996
- US Federal Reviewer for the Intergovernmental Panel on Climate Change working group III 1995 Report on Socioeconomics
- NSF Principal for the Committee on the Environment and Natural Resources' Subcommittee on Risk Assessment, 1993–1996. Also served as the liaison between the Subcommittee on Risk Assessment and the Subcommittee on Social and Economic Sciences
- Advisory panel member for Environmental Ethics and Risk Management, National Academy of Public Administration and George Washington University, 1993–1994
- Science Advisory Board member for Consortium for International Earth Science Information Network, 1993
- Review Panel member for Economics and the Value of Information, NOAA, 1993
- NSF technical representative to the FCCSET Ad Hoc Working Group on Risk Assessment and member of its Subcommittee on Risk Assessment, 1992–1993
- NSF representative to Working Party of the FCCSET Subcommittee for Global Change Research on Assessment, 1992–1993
- Affirmative Action Representative for the Energy Division, Oak Ridge National Laboratory 1984–1989, AA Rep for the Central Management Organization of ORNL, October 1989 to November 1990
- Board of Directors, Vice President (1987–1988), President (1988–1989), Matrix Organization, The Business Center for Women and Minorities, Knoxville, TN

Editorships and Editorial Review Boards

- Editorial Board, *Journal of Risk Analysis*, 1997–present
- Editorial Board, *Journal of Risk Research*, 1997–2005

Peer Reviewer

- The Energy Journal, Climate Change, Contemporary Economic Policy, Growth and Change, Ecological Applications, Risk Analysis, Duke University Press, Princeton University Press, J. of Environmental Economics and Management, Resources and Energy, The Environmental Professional, Journal of Risk Research, National Science Foundation, National Oceanic and Atmospheric Administration, FORUM, U.S. Environmental Protection Agency

Professional Affiliations

- American Economic Association
- Women's Council on Energy and the Environment
- Society for Risk Analysis
  - – President, Society for Risk Analysis, 2002
  - – President-Elect, Society for Risk Analysis, 2001
  - – Councilor, Society for Risk Analysis, 1996–1999
- American Bar Association

Deposition /Trial Testimony

Available on request