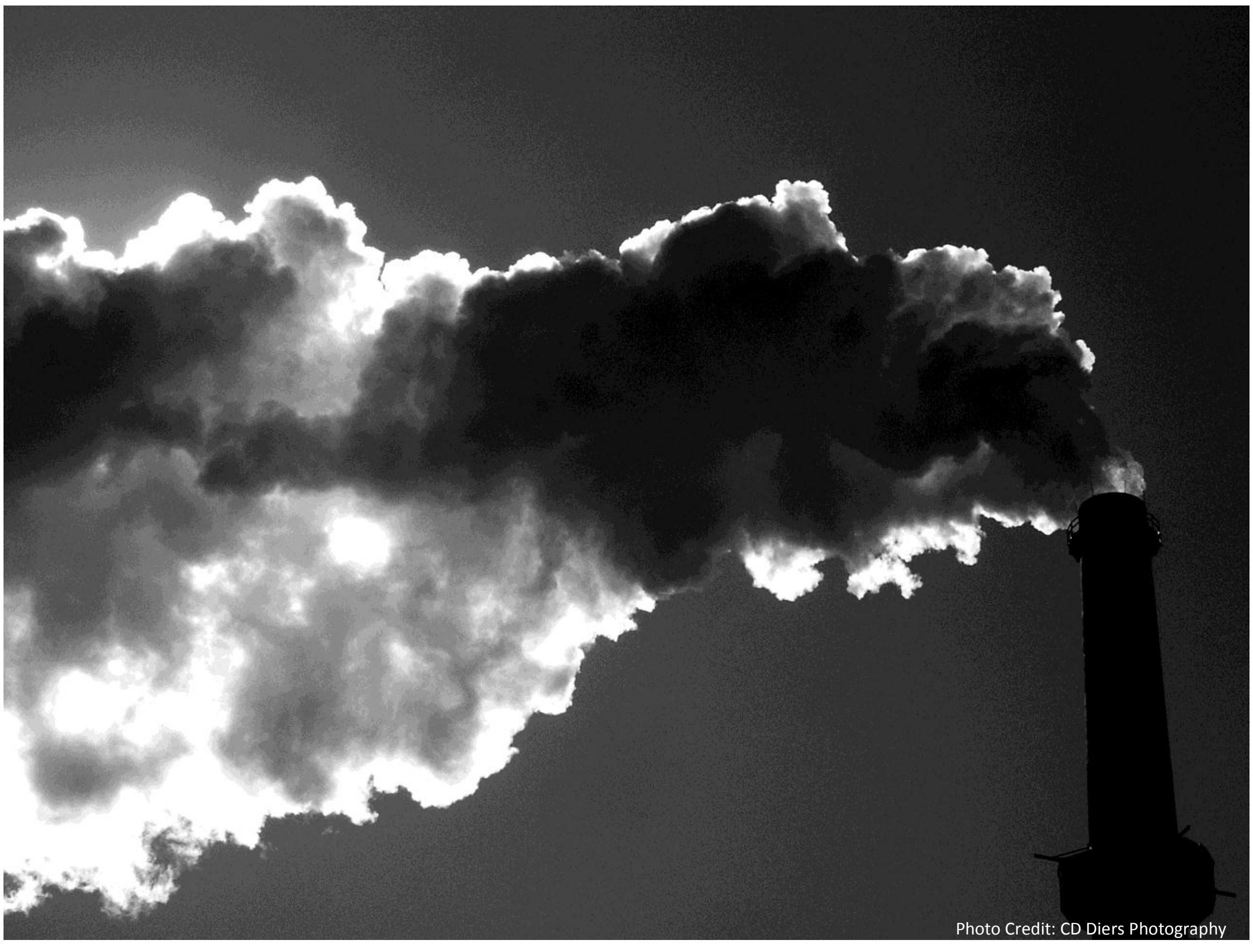
Net Loss: Comparing the Cost of Pollution vs. the Value of Electricity from 51 Coal-Fired Plants



ENVIRONMENTAL INTEGRITY PROJECT

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About the Environmental Integrity Project

The Environmental Integrity Project (EIP) is a nonpartisan, nonprofit organization dedicated to the enforcement of the nation's anti-pollution laws and to the prevention of political interference with those laws. EIP provides objective analysis of how the failure to enforce or implement environmental laws increases pollution and harms public health. We also help local communities obtain the protection of environmental laws.

Acknowledgement

Boston University School of Public Health professor Dr. Jonathan Levy and Environmental Integrity Project Research Analyst Robbie Orvis and Executive Director Eric Schaeffer contributed to this report

Data Limitations

EIP's analysis of air emissions, and health and economic impacts is based on publicly available data retrieved from EPA, state agencies and private companies. Occasionally, government data may contain errors, either because information is inaccurately reported by the regulated entities or incorrectly transcribed by government agencies. In addition, this report is based on data retrieved between August 2011 and May 2012, and subsequent data retrievals may differ slightly as some companies and agencies correct prior reports.

EIP is committed to ensuring that the data we present are as accurate as possible. We will correct any verifiable errors.

Questions and comments can be directed to Robbie Orvis at rorvis@environmentalintegrity.org

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Executive Summary

More than 130 thousand people die every year of heart and lung diseases that result from inhaling particles smaller than the width of a human hair.[a] Coal-fired power plants are a major source of this pollution, which is caused by sulfur dioxide, nitrogen oxides, and unburned particles released from boiler stacks. Fine particle exposure is starting to decline in many areas, as utilities install scrubbers and other pollution control equipment to meet long-delayed Clean Air Act requirements. But some plants have yet to install the advanced pollution controls that have been commercially available for many years. Meanwhile, the coal industry's allies in Congress are seeking to delay or weaken standards, arguing that even the dirtiest plants are so economically valuable, they ought to be exempt from requirements their competitors have already met.

A closer look suggests that the social cost of many of the dirtiest plants – taking into account the premature deaths caused by their pollution – far outweighs the value of the energy they produce. EIP identified 51 plants with the largest emissions of sulfur dioxide in 2010 and 2011 that do not yet have plans to install or upgrade scrubbers (according to the best available information). Dr. Jonathan Levy of the Boston University School of Public Health estimated the premature deaths in 2011 due to fine particle exposures caused by emissions of sulfur dioxide, nitrogen oxides, and particulate matter from each of these plants, using a peer-reviewed approach consistent with EPA methods and using an upper and lower bound for premature mortality based on two benchmark studies the Agency has relied upon in rulemaking. These estimates take into account emissions as well as other factors, such as the size of the population downwind of each plant.

Some of our key findings:

- Dr. Levy found that emissions from the 51 plants contributed to between 2,700 and 5,700 premature deaths in 2011 alone (see Table 2 at end of Executive Summary). Based on Dr. Levy's estimates, these pollution-related premature deaths were highest at the following

[a] Neal Fann et al., *Estimating the National Public Health Burden Associated with Exposure to Ambient $PM_{2.5}$ and Ozone*, 32 Risk Analysis 1, 8 (2011).

plants: Labadie, MO (140 to 290); Eastlake, OH (120 to 240); Yates, GA (110 to 220); Martin Lake, TX (100 to 220); and Mill Creek, KY (100 to 210).

- Americans place a high value on human life and Dr. Levy estimated a social cost, applying the standard statistical value used by EPA, of $23 to $47 billion from the 2,700 to 5,700 premature deaths linked to fine particulate matter pollution from the 51 plants in our study.

- EIP compared these social costs to the estimated retail value of electricity generated at each plant in 2011, relying on data from the U.S. Energy Information Administration (see Appendix A for full results). Using the most conservative benchmark in the study, 18 of the 51 plants in this survey contribute to premature deaths that cost society more than the estimated retail value of the electricity they generated in 2011 (see Table 1).

Table 1: Coal Plants with Social Costs Greater Than Retail Value of Electricity in 2011

PLANT INFORMATION		*HEALTH*	*COST OF PREMATURE DEATHS*	*RETAIL VALUE OF ELECTRICITY*	*RETAIL SALES - SOCIAL COST*
State	**Plant Name**	**2011 Premature Deaths**	**Millions of Dollars**	**Millions of Dollars**	**Millions of Dollars**
AL	Greene County	49 - 100	$410 - $850	$220	($190) - ($630)
GA	Jack McDonough	40 - 82	$330 - $680	$211	($119) - ($469)
GA	Yates	100 - 220	$870 - $1800	$409	($461) - ($1,391)
KY	Green River	44 - 88	$360 - $730	$61	($299) - ($669)
KY	Mill Creek	100 - 210	$870 - $1700	$644	($226) - ($1,056)
KY	Shawnee	70 - 140	$580 - $1200	$557	($23) - ($643)
MI	Trenton Channel	56 - 110	$460 - $950	$358	($102) - ($592)
MO	Meramec	57 - 110	$470 - $950	$457	($13) - ($493)
NC	H F Lee Steam Electric Plant	19 - 39	$160 - $330	$102	($58) - ($228)
NC	L V Sutton	24 - 48	$200 - $400	$125	($75) - ($275)
OH	Eastlake	120 - 240	$980 - $2000	$605	($375) - ($1,395)
SC	Canadys Steam	37 - 75	$300 - $620	$138	($162) - ($482)
TN	Johnsonville	85 - 170	$700 - $1400	$431	($269) - ($969)
TX	Big Brown	94 - 200	$780 - $1700	$726	($54) - ($974)
VA	Yorktown Power Station	34 - 68	$280 - $570	$124	($156) - ($446)
WI	Nelson Dewey	29 - 61	$240 - $500	$108	($132) - ($392)
WV	Kammer	48 - 98	$400 - $810	$140	($260) - ($670)
WV	Phil Sporn	27 - 53	$220 - $440	$118	($102) - ($322)

- For example, Dr. Levy estimates that fine particle pollution from the Southern Company's Yates plant in Georgia contributed to between 100 and 220 deaths in 2011, at a cost to society of between 800 million and 1.8 billion dollars. The retail value of the electricity the plant generated in 2011 was estimated to be roughly $400 million, which means that the social cost of premature mortality caused by the plant's pollution was between $450 million and $1.4 billion greater than the value of the electricity it generated.

- When using the upper bound to estimate premature deaths, an additional 20 plants had social costs exceeding the estimated retail value of their electricity in 2011 (see Appendix A).

- We have estimated the retail value of the electricity generated by each plant based on statewide retail prices of electricity and electricity generation at each plant. These values are likely to be much higher than the actual revenues these plants earn from the sale of power, which are more closely related to wholesale prices that are typically half of what customers actually pay for their electricity (retail values include distribution and other costs that arise after generation). Were the comparison based on actual revenues that plants earn from generating power, the comparison above would be even less favorable. (Data limitations precluded the use of wholesale prices to estimate revenues for specific plants).

- Our estimates also exclude emissions of fine particulates resulting from periods of startup, shutdown, and maintenance, when these emissions can be significant and are often uncontrolled. Were emissions from these events to be included, the social costs of the plants in our study would likely be much higher. Nor does this report include additional costs related to respiratory diseases linked to fine particle pollution (e.g., by estimating the value of lost work days), or the acid rain or climate change impacts of coal combustion, due to the difficulty of estimating these costs for specific plants.

Some of the units at plants identified in this study are scheduled for retirement. Their owners have made the responsible decision to remove aging, inefficient, and dirty power sources that cost society more than the value of the electricity they provide. Their example should serve to inspire others within the industry.

Coal helped to power America's industrial revolution, and electricity is obviously vital to our economy today. But we have better choices now than we had more than forty years ago, when most of these plants were built. Investments in advanced emission controls can greatly reduce the dangerous buildup of fine particles, and investments in renewable energy and efficiency improvements can secure our supply of electricity – and generate the jobs we need – without the death and disease that are the price we pay for dirty coal plants.

Table 2: Range of Premature Deaths from Pollution at Selected Power Plants, 2011[b]

PLANT INFORMATION		*EMISSIONS (TONS)*			*2011 PREMATURE DEATHS*	
State	**Plant Name**	**2011 SO_2**	**2011 NO_x**	**2010 $PM_{2.5}$**	**ACS**	**HSC**
AL	*Colbert*	*18,483*	*8,491*	*36*	*43*	*87*
AL	Greene County	29,945	4,691	70	49	100
AR	Independence	30,398	13,411	378	76	160
FL	Seminole (136)	14,970	2,078	260	22	54
GA	Jack McDonough	18,307	3,162	389	40	82
GA	Yates	47,530	6,763	828	100	220
IA	George Neal South	15,053	4,572	397	16	36
IA	Walter Scott Jr. Energy Center	15,043	7,993	951	22	48
IL	Joppa Steam	26,180	4,810	264	62	130
IL	Kincaid Station	11,790	11,633	57	38	78
IN	Petersburg	25,232	9,667	185	72	150
KY	Green River	17,250	1,793	22	44	88
KY	Mill Creek	29,945	8,494	979	100	210
KY	Shawnee	27,770	15,677	421	70	140
LA	Big Cajun 2	38,719	12,219	875	50	110
LA	Dolet Hills Power Station	20,875	4,841	415	33	71
MI	*J H Campbell*	*26,511*	*7,035*	*43*	*70*	*140*
MI	*St. Clair*	*34,660*	*8,375*	*17*	*76*	*160*
MI	*Trenton Channel*	*22,720*	*5,203*	*31*	*56*	*110*
MO	Labadie	57,947	9,890	1,698	140	290
MO	Meramec	15,282	4,785	175	57	110
MO	New Madrid Power Plant	14,957	8,617	297	39	79
MO	Rush Island	28,036	3,440	242	66	130
MO	Sibley	13,872	2,461	335	14	30
MO	Thomas Hill Energy Center	19,242	8,477	800	24	51
MT	Colstrip	12,225	15,838	1,006	23	53
NC	H F Lee Steam Electric Plant	9,608	2,620	253	19	39
NC	L V Sutton	12,981	4,026	358	24	48
ND	Antelope Valley	13,906	10,548	55	41	92
ND	Coal Creek	15,067	7,977	1,381	48	110
NE	Gerald Gentleman Station	29,113	13,117	94	31	71
OH	Eastlake	48,833	8,440	128	120	240
OH	Gen J M Gavin	33,265	6,984	395	78	160
OH	W H Zimmer Generating Station	18,044	8,438	138	54	110
OK	Grand River Dam Authority	19,023	15,291	454	57	120
OK	Northeastern	17,947	16,237	415	53	110
PA	Bruce Mansfield	21,196	11,550	217	57	110
SC	*Canadys Steam*	*15,632*	*2,654*	*1,279*	*37*	*75*
TN	Gallatin	23,015	5,885	28	55	110
TN	Johnsonville	36,576	7,798	409	85	170
TX	Big Brown	64,198	5,794	472	94	200
TX	Harrington Station	15,106	4,846	142	15	34
TX	Limestone	25,015	14,171	344	44	94
TX	Martin Lake	68,931	15,181	892	100	220
TX	Monticello	54,435	9,236	2,528	86	190
TX	Tolk Station	19,830	6,982	116	20	46
TX	W A Parish	49,570	5,350	514	81	180
VA	Yorktown Power Station	13,942	3,426	171	34	68
WI	Nelson Dewey	11,501	3,231	155	29	61
WV	*Kammer*	*16,712*	*3,590*	*35*	*48*	*98*
WV	*Phil Sporn*	*11,041*	*2,065*	*252*	*27*	*53*
TOTALS		**1,297,430**	**389,855**	**22,399**	**2,700**	**5,700**

[b] Seven plants, italicized in the table above, did not have 2010 $PM_{2.5}$ emissions data, and we have used 2009 data for these facilities. ACS and HSC are the two studies used to estimate premature mortality from fine particle exposure, and represent the lower and upper bounds of our results, respectively. Deaths are rounded to the nearest hundred.

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Introduction

Coal-fired power plants are a major source of fine particle pollution that contributes to heart and lung disease, and to thousands of premature deaths every year. As detailed in the following section, the link between exposure to fine particles and premature death is well established and based on long-term population studies, which have been exhaustively reviewed in the last decade, that screen out other risk factors. The relationship between exposure and mortality is "linear," that is, premature deaths rise and fall in tandem with fine particle levels. EPA models that take into account stack height, wind direction, and other environmental factors are used to estimate ambient pollution levels based on each plant's emissions. Because these models are able to predict the changes in air quality from pollution at power plants, and the relationship between exposure and mortality is linear, it is possible to estimate the impact on premature mortality from emissions at specific power plants.

We asked Dr. Jonathan Levy of the Boston University School of Public Health to apply a simplified version of these models to calculate the premature mortality and its associated social cost caused by emissions from 51 power plants that do not have modern scrubbers, and have not announced plans to install any. The social costs were then compared to the retail value of electricity generated by these plants. The sections that follow explain the methodology used for this analysis, along with its limitations, and explain the conclusions that we reached.

Dr. Levy's expertise includes extensive research on the relationship between emissions, fine particle exposure, and premature mortality. He has served on a number of national advisory committees, including the National Research Council's "Science and Decisions" committee and the Committee on Science for the Environmental Protection Agency's (EPA) Future, as well as the Advisory Council on Clean Air Compliance Analysis, which advises EPA on the impacts of the Clean Air Act on health, the economy, and the environment.[c] A statement from Dr. Levy explaining his calculations is also included in Attachment B, along with his curriculum vitae.

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[c] For more information on Dr. Levy, please visit http://sph.bu.edu/index.php?option=com_sphdir&id=239&Itemid=340&INDEX=16846.

It may sound callous to weigh a human being's life against the sales price of a product, even one as valuable as electricity. But no form of energy is risk-free, e.g., we continue to drive cars despite thousands of highway deaths every year, and we often weigh competing values when making decisions without consciously evaluating the tradeoffs. Our analysis makes clear that pollution from plants without up-to-date emission controls imposes significant social costs that can outweigh the retail value of the electricity they provide.

Power Plant Pollution and Ambient Fine Particulate Matter

Particulate matter (PM) and specifically fine PM or $PM_{2.5}$ is a byproduct of burning fossil fuels, especially coal, and is extremely harmful to human health. PM is a "complex mixture of extremely small particles and liquid droplets [that is] made up of a number of components including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles."[d] Fine PM is the subset of PM that is no larger than 2.5 micrometers in diameter.[e] These tiny particles are of particular concern because they are small enough to penetrate deep into the lungs and lead to serious health problems.[f] Some of the potential health impacts of fine PM exposure are increased respiratory symptoms; decreased lung function; aggravated asthma; development of chronic bronchitis; heart attacks; and premature death in people with heart or lung disease.[g]

While fine particulate matter is formed directly through the combustion process at coal fired power plants (known as "primary" $PM_{2.5}$), it is also created when sulfur oxides (SO_x) and nitrogen oxides (NO_x), react to form "secondary" forms of $PM_{2.5}$, such as sulfates and nitrates.[h] Because emissions of SO_x and NO_x tend to be much greater than $PM_{2.5}$, secondary $PM_{2.5}$ actually makes up most fine particle pollution in the U.S.[i]

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[d] EPA, Particulate Matter, *available at:* http://www.epa.gov/pm/index.html.
[e] *Id.*
[f] EPA, Particulate Matter: Health, *available at*: http://www.epa.gov/pm/health.html.
[g] *Id.*
[h] EPA, Particulate Matter: Basic Information, *available at*: http://www.epa.gov/pm/basic.html.
[i] *Id.*

Selection of Plants for Study

EIP selected the 60 plants with the highest two year (2010-2011) emissions of SO_2 as reported to EPA's Clean Air Markets and no plans to install flue gas desulfurization units (based on a review of the McIlvaine Utility Upgrade Tracking System) for our analysis. Plants incompatible with our methodology were filtered out, e.g., because we could not determine fine particle emissions or the data could not be run using Dr. Levy's model. We next evaluated whether significant changes had taken place at any of these plants from 2010 to 2011 by looking at percentage reductions in emissions rates of SO_2 or NO_x. Five plants that had emissions reductions of SO_2 or NO_x of greater than 20% were eliminated, resulting in a final list of 51 plants (see Table 3). At a few of these plants, some or all of the units are scheduled for retirement. For example, Progress Energy has stated that it will shut down three units at the H.F. Lee Steam Electric Plant in North Carolina by 2013.

Determining Emissions from Target Plants

Power plants are required under Title IV of the Clean Air Act to continuously monitor emissions of SO_2 and NO_x, verify the accuracy of these emissions, and submit this data to EPA on a quarterly basis.[j] EPA posts the data on the "Clean Air Markets" website at http://ampd.epa.gov/ampd/, and the annual emissions of SO_2 and NO_x from that database for 2009 through 2011 were provided to Dr. Levy for use in calculating the formation of secondary particles for each of the 51 plants in the study.

Primary particles are released directly from the stack, and annual releases are estimated based on extrapolations from occasional three hour stack tests, or by calculating releases based on such factors as the ash content and volume of coal burned, and the type of emission controls in place. These estimates are summed up in annual emission inventory reports provided to state agencies every year, and EIP provided this data to Dr. Levy for use in calculating their contribution to fine particle formation at each of the 51 plants. In some cases, plants reported only emissions of larger particles, without identifying (or "speciating") the

[j] Emissions data for SO_2 and NO_x were obtained through EPA's Clean Air Markets website.

Table 3: Emissions of SO_2, NO_x, and $PM_{2.5}$ from Select Power Plants

PLANT INFORMATION		***EMISSIONS (TONS)***		
State	**Plant Name**	**2011 SO_2**	**2011 NO_x**	**2010[k] $PM_{2.5}$**
AL	Colbert	18,483	8,491	36
AL	Greene County	29,945	4,691	70
AR	Independence	30,398	13,411	378
FL	Seminole (136)	14,970	2,078	260
GA	Jack McDonough	18,307	3,162	389
GA	Yates	47,530	6,763	828
IA	George Neal South	15,053	4,572	397
IA	Walter Scott Jr. Energy Center	15,043	7,993	951
IL	Joppa Steam	26,180	4,810	264
IL	Kincaid Station	11,790	11,633	57
IN	Petersburg	25,232	9,667	185
KY	Green River	17,250	1,793	22
KY	Mill Creek	29,945	8,494	979
KY	Shawnee	27,770	15,677	421
LA	Big Cajun 2	38,719	12,219	875
LA	Dolet Hills Power Station	20,875	4,841	415
MI	J H Campbell	26,511	7,035	43
MI	St. Clair	34,660	8,375	17
MI	Trenton Channel	22,720	5,203	31
MO	Labadie	57,947	9,890	1,698
MO	Meramec	15,282	4,785	175
MO	New Madrid Power Plant	14,957	8,617	297
MO	Rush Island	28,036	3,440	242
MO	Sibley	13,872	2,461	335
MO	Thomas Hill Energy Center	19,242	8,477	800
MT	Colstrip	12,225	15,838	1,006
NC	H F Lee Steam Electric Plant	9,608	2,620	253
NC	L V Sutton	12,981	4,026	358
ND	Antelope Valley	13,906	10,548	55
ND	Coal Creek	15,067	7,977	1,381
NE	Gerald Gentleman Station	29,113	13,117	94
OH	Eastlake	48,833	8,440	128
OH	Gen J M Gavin	33,265	6,984	395
OH	W H Zimmer Generating Station	18,044	8,438	138
OK	Grand River Dam Authority	19,023	15,291	454
OK	Northeastern	17,947	16,237	415
PA	Bruce Mansfield	21,196	11,550	217
SC	Canadys Steam	15,632	2,654	1,279
TN	Gallatin	23,015	5,885	28
TN	Johnsonville	36,576	7,798	409
TX	Big Brown	64,198	5,794	472
TX	Harrington Station	15,106	4,846	142
TX	Limestone	25,015	14,171	344
TX	Martin Lake	68,931	15,181	892
TX	Monticello	54,435	9,236	2,528
TX	Tolk Station	19,830	6,982	116
TX	W A Parish	49,570	5,350	514
VA	Yorktown Power Station	13,942	3,426	171
WI	Nelson Dewey	11,501	3,231	155
WV	Kammer	16,712	3,590	35
WV	Phil Sporn	11,041	2,065	252
Total		**1,297,430**	**389,855**	**22,399**

[k] Seven plants, italicized in the table above, have 2009 $PM_{2.5}$ emissions data.

fraction smaller than 2.5 microns. EIP adjusted those estimates to determine the fine particle component using EPA's AP-42 emission factors, and applying unit specific information obtained from EPA and the Energy Information Administration (EIA) to obtain the necessary data for the AP-42 calculation (e.g., type of boiler and control technology).

Data for $PM_{2.5}$ emissions is not yet available for 2011, so we have relied on 2010 data, except for seven plants for which the 2009 data was the most recent available: Colbert in Alabama; J H Campbell, St. Clair, and Trenton Channel in Michigan; Bruce Mansfield in Pennsylvania; Canadys Steam in South Carolina; and Kammer and Phil Sporn in West Virginia.

Health Impacts of Power Plant Emissions of Fine Particulate Matter

The impact of fine PM concentrations on human health has been rigorously researched, with studies consistently linking increased levels of fine PM to a range of health outcomes including, most notably, premature morality. Two studies in particular, the Harvard Six Cities (HSC) study and the American Cancer Society (ACS) study are used by EPA as its upper and lower bounds in regulatory impact analyses (i.e. cost benefit analyses) and have been exhaustively reviewed by the scientific community. Both studies are cohorts, meaning they track individuals over time and are based on many years' worth of data. Citing these two studies and their many re-analyses, as well as other studies, EPA has stated unequivocally in its most recent Integrated Science Assessment for particulate matter, that, "**the evidence is sufficient to conclude that the relationship between long-term $PM_{2.5}$ exposures and mortality is causal**."[i] The HSC and ACS studies as well as others, have also found that the relationship between exposure to fine PM and premature mortality is linear, that is, premature deaths rise and fall in tandem with fine particle levels. For his analysis, Dr. Levy used a model he created for a 2009 study that was published in the journal *Risk Analysis* and the emissions estimates we provided him to estimate the health impacts from the power plants identified above (see Table 4 on next page).

[i] EPA, Integrated Science Assessment for Particulate Matter 7-96, December 2009, *available at:* http://www.epa.gov/ncea/isa/.

Table 4: Range of Premature Deaths from Pollution at Selected Power Plants, 2011

PLANT INFORMATION		*2011 PREMATURE DEATHS*	
State	**Plant Name**	**ACS**	**HSC**
AL	Colbert	43	87
AL	Greene County	49	100
AR	Independence	76	160
FL	Seminole (136)	22	54
GA	Jack McDonough	40	82
GA	Yates	100	220
IA	George Neal South	16	36
IA	Walter Scott Jr. Energy Center	22	48
IL	Joppa Steam	62	130
IL	Kincaid Station	38	78
IN	Petersburg	72	150
KY	Green River	44	88
KY	Mill Creek	100	210
KY	Shawnee	70	140
LA	Big Cajun 2	50	110
LA	Dolet Hills Power Station	33	71
MI	J H Campbell	70	140
MI	St. Clair	76	160
MI	Trenton Channel	56	110
MO	Labadie	140	290
MO	Meramec	57	110
MO	New Madrid Power Plant	39	79
MO	Rush Island	66	130
MO	Sibley	14	30
MO	Thomas Hill Energy Center	24	51
MT	Colstrip	23	53
NC	H F Lee Steam Electric Plant	19	39
NC	L V Sutton	24	48
ND	Antelope Valley	41	92
ND	Coal Creek	48	110
NE	Gerald Gentleman Station	31	71
OH	Eastlake	120	240
OH	Gen J M Gavin	78	160
OH	W H Zimmer Generating Station	54	110
OK	Grand River Dam Authority	57	120
OK	Northeastern	53	110
PA	Bruce Mansfield	57	110
SC	Canadys Steam	37	75
TN	Gallatin	55	110
TN	Johnsonville	85	170
TX	Big Brown	94	200
TX	Harrington Station	15	34
TX	Limestone	44	94
TX	Martin Lake	100	220
TX	Monticello	86	190
TX	Tolk Station	20	46
TX	W A Parish	81	180
VA	Yorktown Power Station	34	68
WI	Nelson Dewey	29	61
WV	Kammer	48	98
WV	Phil Sporn	27	53
Total Deaths (Rounded)		**2,700**	**5,700**

Dr. Levy's methodology is described in more detail below:

> The analysis here uses standard methods for health externality assessment, similar to the approach used by US EPA when modeling the health benefits of environmental regulations. This includes estimating emissions from each power plant, applying atmospheric dispersion models to determine how those emissions influence air pollution levels, and using epidemiological evidence to determine a concentration-response function and calculate the public health burden associated with those air pollution levels. The model used in this report, which was originally developed for the 2009 publication "Uncertainty and Variability in Health-Related Damages from Coal-Fired Power Plants in the United States" and focused on mortality risks from primary and secondary fine particulate matter ($PM_{2.5}$) from 407 coal-fired power plants across the United States, relies on a county-resolution source-receptor matrix. While simplified relative to state-of-the-science atmospheric dispersion models, prior analyses have shown that health risk estimates were similar using this model and more complex models, and plant-specific estimates for many power plants would be computationally challenging using more complex atmospheric models, such as CMAQ. Additionally, the model used in the 2009 publication has been updated for this analysis by replacing 2000 Census data with 2010 Census data, updating the per capita mortality rate to reflect 2003-2007 rates (instead of 1999-2003 rates), and utilizing upper and lower bound externality functions that are in line with the Harvard Six Cities and American Cancer Society studies used in EPA rulemakings.[m]

Dr. Levy's analysis applies the benchmark HSC and ACS studies to estimate the $PM_{2.5}$ concentrations that can be attributed to the 2011 emissions in Table 3. The estimated impact on premature mortality from these emissions is listed above in Table 4. As Table 4 shows, Dr. Levy estimated that emissions of SO_2, NO_x, and $PM_{2.5}$ from the facilities above led to between 2,700 and 5,700 premature deaths in 2011.

Cost of Premature Mortality from Power Plant Emissions

Exposure to fine particles cuts thousands of lives short every year. To calculate how much this costs society, Dr. Levy multiplied the EPA Value of Statistical Life (VSL) of $7.4 million in 2006 dollars ($8.3 million in 2012 dollars) by the premature deaths at each plant. The VSL is a statistic used by the EPA to determine the economic benefits or costs of changes in

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[m] The studies used for externality functions are: 1) For the HSC analysis: Schwartz J, Coull B, Laden F, et al. The effect of dose and timing of dose on the association between airborne particles and survival. *Environ Health Perspect* 2008;116(1):64-9; and 2) For the ACS analysis: Krewski D, Jerrett M, Burnett RT, et al. Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. Res Rep Health Eff Inst 2009(140):5-114; discussion 5-36. For more information on Dr. Levy's methodology, please see: Levy JI, Baxter LK, Schwartz J. Uncertainty and variability in health-related damages from coal-fired power plants in the United States. Risk Anal 2009; 29(7):1000-14.

premature mortality (typically associated with changes in air quality) and is used in Agency rulemakings.[n] The VSL reflects the amount of money a group of people is willing to pay to reduce premature mortality by a given amount.[o] As Dr. Levy has noted, here, because of rounding in calculations, the monetary cost of premature death as reported in Table 5 divided by the number of premature deaths in Table 4 will not precisely equal $8.3 million.

Applying the VSL to the estimated number of deaths resulting from each plant's pollution, Dr. Levy estimated the 51 plants in our survey imposed social costs of between $23 and $47 billion a year in 2011. All values reported reflect central estimates, using direct outputs from the source-receptor matrix, central estimates from each of the concentration-response functions, and $8.3 million as a value of statistical life. With a cost of between $23 and $47 billion, reducing pollution from these plants will not only save lives, but also have significant economic benefits.

EIP's analysis is limited to the cost of pollution associated with premature mortality from primary and secondary fine particulate matter, and does not attempt to monetize the many other health and environmental impacts from coal plant emissions. For example, a 2011 study authored by Dr. Paul Epstein – who was at that time Associate Director of Harvard Medical School Center for Health and the Global Environment – and published in the Annals of the New York Academy of Science concluded that, in 2008 dollars, greenhouse gas emissions from coal combustion imposed nearly $20 billion a year in environmental costs, while the public health impact of coal mining in Appalachia totaled nearly $75 billion a year.[p]

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[n] For example, see: EPA, Regulatory Impact Analysis for the Final Mercury and Air Toxics Standards 5-40, *available online at*: http://www.epa.gov/ttn/atw/utility/mats_final_ria_v2.pdf.

[o] For more information on the VSL, see: http://yosemite.epa.gov/ee/epa/eed.nsf/pages/MortalityRiskValuation.html.

[p] Paul R. Epstein et al., *Full Cost Accounting for the Life Cycle of Coal*, 1219 Annals of the New York Academy of Sciences 73, 91 (2011).

Table 5: Costs of Premature Deaths from Pollution at Selected Power Plants

PLANT INFORMATION		*2011 COST OF PREMATURE DEATHS*	
State	**Plant Name**	**ACS**	**HSC**
AL	Colbert	$350,000,000	$720,000,000
AL	Greene County	$410,000,000	$850,000,000
AR	Independence	$630,000,000	$1,300,000,000
FL	Seminole (136)	$190,000,000	$450,000,000
GA	Jack McDonough	$330,000,000	$680,000,000
GA	Yates	$870,000,000	$1,800,000,000
IA	George Neal South	$140,000,000	$300,000,000
IA	Walter Scott Jr. Energy Center	$180,000,000	$400,000,000
IL	Joppa Steam	$510,000,000	$1,000,000,000
IL	Kincaid Station	$310,000,000	$640,000,000
IN	Petersburg	$600,000,000	$1,200,000,000
KY	Green River	$360,000,000	$730,000,000
KY	Mill Creek	$870,000,000	$1,700,000,000
KY	Shawnee	$580,000,000	$1,200,000,000
LA	Big Cajun 2	$410,000,000	$890,000,000
LA	Dolet Hills Power Station	$280,000,000	$590,000,000
MI	J H Campbell	$580,000,000	$1,200,000,000
MI	St. Clair	$630,000,000	$1,300,000,000
MI	Trenton Channel	$460,000,000	$950,000,000
MO	Labadie	$1,200,000,000	$2,400,000,000
MO	Meramec	$470,000,000	$950,000,000
MO	New Madrid Power Plant	$320,000,000	$660,000,000
MO	Rush Island	$550,000,000	$1,100,000,000
MO	Sibley	$110,000,000	$250,000,000
MO	Thomas Hill Energy Center	$200,000,000	$420,000,000
MT	Colstrip	$190,000,000	$440,000,000
NC	H F Lee Steam Electric Plant	$160,000,000	$330,000,000
NC	L V Sutton	$200,000,000	$400,000,000
ND	Antelope Valley	$340,000,000	$760,000,000
ND	Coal Creek	$400,000,000	$890,000,000
NE	Gerald Gentleman Station	$260,000,000	$590,000,000
OH	Eastlake	$980,000,000	$2,000,000,000
OH	Gen J M Gavin	$650,000,000	$1,300,000,000
OH	W H Zimmer Generating Station	$450,000,000	$900,000,000
OK	Grand River Dam Authority	$470,000,000	$990,000,000
OK	Northeastern	$440,000,000	$930,000,000
PA	Bruce Mansfield	$470,000,000	$950,000,000
SC	Canadys Steam	$300,000,000	$620,000,000
TN	Gallatin	$450,000,000	$920,000,000
TN	Johnsonville	$700,000,000	$1,400,000,000
TX	Big Brown	$780,000,000	$1,700,000,000
TX	Harrington Station	$120,000,000	$280,000,000
TX	Limestone	$360,000,000	$780,000,000
TX	Martin Lake	$840,000,000	$1,800,000,000
TX	Monticello	$710,000,000	$1,500,000,000
TX	Tolk Station	$170,000,000	$380,000,000
TX	W A Parish	$670,000,000	$1,500,000,000
VA	Yorktown Power Station	$280,000,000	$570,000,000
WI	Nelson Dewey	$240,000,000	$500,000,000
WV	Kammer	$400,000,000	$810,000,000
WV	Phil Sporn	$220,000,000	$440,000,000
Total Cost (Rounded)		**$22,800,000,000**	**$47,400,000,000**

In addition to premature mortality, exposure to fine particle pollution also triggers asthma attacks, chronic bronchitis, and other diseases that cost society more than 6 billion dollars per year (in 2010 dollars).[q] While these additional impacts can be monetized, we considered only the social cost of premature mortality linked to fine particle pollution caused by the plants in our study for two reasons. First, studies by EPA show that premature mortality contributes the majority of monetized health impacts. Second, we wanted to rely on previously published and peer-reviewed methods that could be applied directly to these 51 power plants, and the study by Levy et al. (2009) only included premature mortality.

Retail Value of Electricity Compared to Social Costs

There are two ways to value sales of electricity. The first is to use the retail price of electricity, or the amount that households and other end users pay for electricity. The other is to use wholesale prices of electricity, which are the values that plants usually receive for selling the energy they produce. The difference between these prices, which can be substantial (retail is typically 2-3 times higher than wholesale, as demonstrated below) is usually due to costs associated with the distribution of energy. In Table 6 below, we have estimated the values of sales of electricity at select power plants using the *retail* value of electricity in the states where each plant is located, as reported by the Energy Information Administration. The estimated retail value of electricity sold at each power plant is calculated by multiplying the net generation at each plant, or the total amount of energy it produces less what it uses to operate, by the plant's state-wide average retail price of energy.

We were unable to obtain information on actual sales, as such information is not readily available to the public. Estimating the retail value of a plant's net generation suffers from several limitations:

- The mix of customers a plant serves will affect its revenues, as prices vary by sector (e.g., industrial vs. residential), and may also be affected by long term contracts;
- Power plants frequently sell to customers in other states; and

[q] Clean Air Task Force, The Toll From Coal: An Updated Assessment of Death and Disease from America's Dirtiest Energy Source 10 (2010).

Table 6: Retail Value of Electricity Generation at Select Power Plants

PLANT INFORMATION		*NET GENERATION (MWH)*	*STATE RETAIL PRICE OF ELECTRICITY ($/MWH)*	*TOTAL REVENUES FROM ELECTRICITY GENERATION*
State	**Plant Name**	**2011**	**2011**	**2011**
AL	Colbert	4,772,848	$92.10	$439,579,301
AL	Greene County	2,393,674	$92.10	$220,457,375
AR	Independence	10,994,484	$74.60	$820,188,506
FL	Seminole (136)	8,457,157	$107.70	$910,835,809
GA	Jack McDonough	2,191,212	$96.50	$211,451,958
GA	Yates	4,239,814	$96.50	$409,142,051
IA	George Neal South	4,280,672	$75.90	$324,903,005
IA	Walter Scott Jr. Energy Center	11,987,286	$75.90	$909,835,007
IL	Joppa Steam	7,709,230	$90.10	$694,601,623
IL	Kincaid Station	5,104,909	$90.10	$459,952,301
IN	Petersburg	10,052,634	$80.40	$808,231,774
KY	Green River	853,667	$71.10	$60,695,724
KY	Mill Creek	9,061,573	$71.10	$644,277,840
KY	Shawnee	7,838,983	$71.10	$557,351,691
LA	Big Cajun 2	12,767,371	$77.40	$988,194,515
LA	Dolet Hills Power Station	4,731,881	$77.40	$366,247,589
MI	J H Campbell	8,382,991	$103.70	$869,316,167
MI	St. Clair	6,137,133	$103.70	$636,420,692
MI	Trenton Channel	3,450,390	$103.70	$357,805,443
MO	Labadie	18,590,796	$83.50	$1,552,331,466
MO	Meramec	5,473,893	$83.50	$457,070,066
MO	New Madrid Power Plant	7,287,062	$83.50	$608,469,677
MO	Rush Island	8,230,314	$83.50	$687,231,219
MO	Sibley	2,381,498	$83.50	$198,855,083
MO	Thomas Hill Energy Center	8,137,999	$83.50	$679,522,917
MT	Colstrip	13,025,219	$82.30	$1,071,975,524
NC	H F Lee Steam Electric Plant	1,359,458	$74.90	$101,823,404
NC	L V Sutton	1,673,868	$74.90	$125,372,713
ND	Antelope Valley	5,327,252	$78.40	$417,656,557
ND	Coal Creek	8,536,104	$78.40	$669,230,554
NE	Gerald Gentleman Station	9,355,988	$147.50	$1,380,008,230
OH	Eastlake	6,682,182	$90.50	$604,737,471
OH	Gen J M Gavin	18,184,347	$90.50	$1,645,683,404
OH	W H Zimmer Generating Station	6,752,565	$90.50	$611,107,133
OK	Grand River Dam Authority	6,804,512	$78.30	$532,793,290
OK	Northeastern	8,687,676	$78.30	$680,245,031
PA	Bruce Mansfield	18,045,568	$104.90	$1,892,980,083
SC	Canadys Steam	1,558,389	$88.60	$138,073,265
TN	Gallatin	7,285,856	$91.40	$665,927,238
TN	Johnsonville	4,712,457	$91.40	$430,718,570
TX	Big Brown	7,910,643	$91.80	$726,197,027
TX	Harrington Station	5,749,811	$91.80	$527,832,650
TX	Limestone	13,484,068	$91.80	$1,237,837,442
TX	Martin Lake	17,619,350	$91.80	$1,617,456,330
TX	Monticello	12,477,984	$91.80	$1,145,478,931
TX	Tolk Station	7,815,928	$91.80	$717,502,190
TX	W A Parish	17,968,410	$91.80	$1,649,500,038
VA	Yorktown Power Station	1,400,741	$88.70	$124,245,727
WI	Nelson Dewey	1,056,704	$102.30	$108,100,819
WV	Kammer	1,778,385	$78.80	$140,136,738
WV	Phil Sporn	1,492,068	$78.80	$117,574,958
Total				**$33,953,164,116**

- Retail prices include distribution and other costs that arise after electricity is generated, and are typically twice as high as the wholesale rates that would provide a truer measure of the price that power plants receive for their electricity.

Table 7 below demonstrates the difference between wholesale and retail prices at several major energy hubs around the country:

Table 7: Wholesale and Retail Energy Prices at Select Energy Hubs, 2009-2010

State	Power Hub	2009			2010		
		Wholesale	*Retail*	*Retail as a Percent of Wholesale*	*Wholesale*	*Retail*	*Retail as a Percent of Wholesale*
AR	Entergy Peak	$33.18	$75.70	228%	$41.65	$72.80	175%
CA	SP-15 Gen DA LMP Peak	$37.49	$132.40	353%	$41.44	$130.10	314%
DC	PJM-West	$46.31	$129.70	280%	$55.92	$133.50	239%
LA	Entergy Peak	$33.18	$70.60	213%	$41.65	$78.00	187%
MA	Nepool MH DA LMP	$49.66	$154.50	311%	$58.02	$142.60	246%
MD	PJM-West	$46.31	$130.80	282%	$55.92	$127.00	227%
MI	AEP Dayton Peak	$39.56	$94.00	238%	$50.48	$98.80	196%
MS	Entergy Peak	$33.18	$88.50	267%	$41.65	$85.90	206%
OH	AEP Dayton Peak	$39.56	$90.10	228%	$50.48	$91.40	181%
PA	PJM-West	$46.31	$96.00	207%	$55.92	$103.10	184%
S. TX	ERCOT-South	$43.44	$96.00	221%	$42.87	$103.10	240%
TX	Entergy Peak	$33.18	$98.60	297%	$41.65	$93.40	224%

Because we were unable to obtain consistent data on wholesale prices in 2011, we elected to estimate the value of each plant's generation based on retail price information. Although this is likely to significantly overstate actual plant revenues (see Table 7), **the social cost of premature deaths alone, excluding all other costs, can outweigh the entire retail value of electricity at a plant.** Table 8 on the next page shows the retail value of electricity generation at each of the plants we evaluated less the social costs of premature mortality from emissions at the plants. Depending on which study is used to estimate premature mortality, these plants can have negative net values that reach into the billions of dollars.

Table 8: Retail Value Less Social Costs at Select Power Plants

PLANT INFORMATION		***TOTAL REVENUES FROM ELECTRICITY GENERATION***	***2011 REVENUE - SOCIAL COST***	
State	**Plant Name**	**2011**	**ACS**	**HSC**
AL	Colbert	$439,579,301	$89,579,301	($280,420,699)
AL	Greene County	$220,457,375	($189,542,625)	($629,542,625)
AR	Independence	$820,188,506	$190,188,506	($479,811,494)
FL	Seminole (136)	$910,835,809	$720,835,809	$460,835,809
GA	Jack McDonough	$211,451,958	($118,548,042)	($468,548,042)
GA	Yates	$409,142,051	($460,857,949)	($1,390,857,949)
IA	George Neal South	$324,903,005	$184,903,005	$24,903,005
IA	Walter Scott Jr. Energy Center	$909,835,007	$729,835,007	$509,835,007
IL	Joppa Steam	$694,601,623	$184,601,623	($305,398,377)
IL	Kincaid Station	$459,952,301	$149,952,301	($180,047,699)
IN	Petersburg	$808,231,774	$208,231,774	($391,768,226)
KY	Green River	$60,695,724	($299,304,276)	($669,304,276)
KY	Mill Creek	$644,277,840	($225,722,160)	($1,055,722,160)
KY	Shawnee	$557,351,691	($22,648,309)	($642,648,309)
LA	Big Cajun 2	$988,194,515	$578,194,515	$98,194,515
LA	Dolet Hills Power Station	$366,247,589	$86,247,589	($223,752,411)
MI	J H Campbell	$869,316,167	$289,316,167	($330,683,833)
MI	St. Clair	$636,420,692	$6,420,692	($663,579,308)
MI	Trenton Channel	$357,805,443	($102,194,557)	($592,194,557)
MO	Labadie	$1,552,331,466	$352,331,466	($847,668,534)
MO	Meramec	$457,070,066	($12,929,935)	($492,929,935)
MO	New Madrid Power Plant	$608,469,677	$288,469,677	($51,530,323)
MO	Rush Island	$687,231,219	$137,231,219	($412,768,781)
MO	Sibley	$198,855,083	$88,855,083	($51,144,917)
MO	Thomas Hill Energy Center	$679,522,917	$479,522,917	$259,522,917
MT	Colstrip	$1,071,975,524	$881,975,524	$631,975,524
NC	H F Lee Steam Electric Plant	$101,823,404	($58,176,596)	($228,176,596)
NC	L V Sutton	$125,372,713	($74,627,287)	($274,627,287)
ND	Antelope Valley	$417,656,557	$77,656,557	($342,343,443)
ND	Coal Creek	$669,230,554	$269,230,554	($220,769,446)
NE	Gerald Gentleman Station	$1,380,008,230	$1,120,008,230	$790,008,230
OH	Eastlake	$604,737,471	($375,262,529)	($1,395,262,529)
OH	Gen J M Gavin	$1,645,683,404	$995,683,404	$345,683,404
OH	W H Zimmer Generating Station	$611,107,133	$161,107,133	($288,892,868)
OK	Grand River Dam Authority	$532,793,290	$62,793,290	($457,206,710)
OK	Northeastern	$680,245,031	$240,245,031	($249,754,969)
PA	Bruce Mansfield	$1,892,980,083	$1,422,980,083	$942,980,083
SC	Canadys Steam	$138,073,265	($161,926,735)	($481,926,735)
TN	Gallatin	$665,927,238	$215,927,238	($254,072,762)
TN	Johnsonville	$430,718,570	($269,281,430)	($969,281,430)
TX	Big Brown	$726,197,027	($53,802,973)	($973,802,973)
TX	Harrington Station	$527,832,650	$407,832,650	$247,832,650
TX	Limestone	$1,237,837,442	$877,837,442	$457,837,442
TX	Martin Lake	$1,617,456,330	$777,456,330	($182,543,670)
TX	Monticello	$1,145,478,931	$435,478,931	($354,521,069)
TX	Tolk Station	$717,502,190	$547,502,190	$337,502,190
TX	W A Parish	$1,649,500,038	$979,500,038	$149,500,038
VA	Yorktown Power Station	$124,245,727	($155,754,273)	($445,754,273)
WI	Nelson Dewey	$108,100,819	($131,899,181)	($391,899,181)
WV	Kammer	$140,136,738	($259,863,262)	($669,863,262)
WV	Phil Sporn	$117,574,958	($102,425,042)	($322,425,042)
Total			**$11,163,164,116**	**($13,406,835,884)**

Emissions During Startup, Shutdown, and Maintenance

When reporting emissions, power plants are typically not required to report emissions during startup, shutdown, and maintenance (SSM) events. During these periods, pollution control technologies are typically not fully operated, if at all, and significant amounts of pollution can be emitted. Baghouses or electrostatic precipitators (ESP's) typically eliminate 99% of the fly ash from coal combustion that would otherwise be released as particle pollution. Failing to operate these controls for even a few hours can have a dramatic impact on emissions.

For example, assume a coal plant has the potential to release 10,000 tons of particulates per year without controls, but releases only one hundred tons (or one percent) of that amount because it has installed an ESP that captures the other 99%. Failing to operate the ESP just one percent of the time would add another 100 tons to total annual emissions, (10,000 x .01 uncontrolled = 100 tons), effectively doubling the pollution (100 tons plus 9900 – (9900 x. 0.99 removal) = 199 tons).

Although particulates released during these "SSM events" are usually not included in annual emission reports, they can add up quickly. For example, Texas power plants have recently filed applications asking for permission to release much greater volumes of particulate matter during startup, shutdown and maintenance than their current permits allow for up to 600 hours a year[r]. Table 9 below shows the additional particulate matter emissions that could result based on permit applications for seven units, compared to the annual amounts now reported to the emissions inventory:

[r] SSM applications have requested limits permitting up to 600 hours a year of SSM events. However, permits awarded by the Texas Council on Environmental Quality (TCEQ) have included no limit on the number of hours of SSM events that are permissible in a given year. Therefore, these permits essentially offer unlimited restrictions on the annual quantity and duration of SSM events.

Table 9: $PM_{2.5}$ Reported Annual Emissions and Requested SSM Emissions at 4 Texas Power Plants

Plant	***Unit***	***2009 (Tons)***			***2010 (Tons)***		
		Annual Normal Operations Emissions	***Additional SSM Emissions Requested***	***Stated Annual SSM Emissions***	***Annual Normal Operations Emissions***	***Additional SSM Emissions Requested***	***Stated Annual SSM Emissions***
LCRA Fayette	1	134.0	62.2	0.0	109.4	62.2	5.7
LCRA Fayette	2	220.4	62.2	0.1	181.4	62.2	14.6
LCRA Fayette	3	45.0	84.2	0.4	52.5	84.2	0.5
Limestone	1	153.1	662.6	0.0	251.0	662.6	27.8
Limestone	2	95.3	662.6	0.0	57.3	662.6	41.3
San Miguel	1	57.3	40.5	0.1	55.6	40.5	0.1
Gibbons Creek	1	139.6	25.2	0.0	140.8	25.2	0.0

As Table 9 demonstrates, the emissions requested in the new SSM permit applications reflect emissions that not only vastly exceed what these companies have reported emitting during these events, but also are a significant fraction of the total annual emissions at each plant (and in some cases actually *exceed* reported annual emissions). And these estimates may understate the potential emissions from SSM events, since they assume that some fine particles would "drop out" of the flue gas before exiting the stack, even when pollution controls are turned off. Were releases during these events included in emissions inventories and calculated correctly, the estimates of primary fine particle emissions used in our analysis would have been significantly higher, as would the resulting premature mortalities and their social cost.

Conclusion

Emissions of $PM_{2.5}$, SO_x, and NO_x from coal fired power plants lead to increases in ambient levels of fine particulate matter that cause premature death. Two long-term health studies known as the American Cancer Society and Harvard Six Cities studies are used by EPA as upper and lower bounds for estimating the change in premature mortality from changes in air quality. Based on these studies, air quality modeling, and the best available emissions data, Dr. Levy estimates that fine particle pollution from the 51 power plants chosen for this study resulted in between 2,700 and 5,700 premature deaths in 2011. Dr. Levy estimates the social cost of these early deaths at between $23 and $47 billion in 2011 alone.

<u>The social cost of these emissions is *so* high, that on a plant-by-plant basis, they often outweigh the entire retail value of electricity at individual power plants that lack up-to-date pollution controls.</u> The emissions data used to determine the health and economic impacts in this study do not take into account additional social costs related to power plant pollution, such as lost work days due to respiratory ailments, or the damage caused by acid rain or climate change. Nor does it include releases of primary particles during startup, shutdown, or maintenance, which could add significantly to fine particle loadings from the 51 plants in the study.

Pollution controls and alternative fuel sources that help control particulate matter emissions and particulate matter precursors from coal fired power plants already exist and are in use by some power plants. For example, modern scrubbers can remove 99% of the sulfur dioxide emissions that are the primary source of secondary fine particle formation caused by power plants. Baghouses can effectively control the release of primary particles from stacks, and do not have to be shut off during startup and shutdown, like some electrostatic precipitators.

Best of all, energy from wind, solar, and other renewable sources can generate electricity without the death and disease that are the price we pay for coal-fired power plants, while sensible conservation programs can ensure that we use that power as efficiently as possible. Power plants that cost society so much more than the revenues they earn for their owners have outlived their purpose, and need to make way for the cleaner and more cost-effective alternatives already at hand.

Appendix A - Table of 2009-2011 Results

PLANT INFORMATION		PREMATURE DEATHS						REVENUES - SOCIAL COSTS (MILLIONS OF DOLLARS)					
		2009		2010		2011		2009		2010		2011	
State	Plant Name	ACS	HSC	ACS	HSC	ACS	HSC	ACS	HSC	ACS	HSC	ACS	HSC
AL	Colbert	37	76	53	110	43	87	($50)	($370)	$97	($363)	$90	($280)
AL	Greene County	52	110	55	110	49	100	($221)	($681)	($217)	($707)	($190)	($630)
AR	Independence	70	140	73	150	76	160	$282	($338)	$266	($334)	$190	($480)
FL	Seminole (136)	31	74	25	61	22	54	$555	$195	$735	$435	$721	$461
GA	Jack McDonough	35	71	37	78	40	82	($107)	($407)	($128)	($468)	($119)	($469)
GA	Yates	100	210	121	243	100	220	($431)	($1,301)	($505)	($1,518)	($461)	($1,391)
IA	George Neal South	13	29	18	40	16	36	$183	$53	$222	$42	$185	$25
IA	Walter Scott Jr. Energy Center	20	43	22	47	22	48	$668	$468	$747	$537	$730	$510
IL	Joppa Steam	57	120	61	120	62	130	$164	($326)	$207	($283)	$185	($305)
IL	Kincaid Station	50	100	49	100	38	78	$212	($228)	$151	($269)	$150	($180)
IN	Petersburg	110	230	85	170	72	150	($89)	($1,059)	$196	($494)	$208	($392)
KY	Green River	37	75	52	100	44	88	($269)	($579)	($370)	($800)	($299)	($669)
KY	Mill Creek	89	180	96	190	100	210	($64)	($824)	($102)	($902)	($226)	($1,056)
KY	Shawnee	69	140	71	140	70	140	($84)	($714)	($63)	($673)	($23)	($643)
LA	Big Cajun 2	46	99	48	100	50	110	$461	$31	$592	$132	$578	$98
LA	Dolet Hills Power Station	21	44	34	71	33	71	$145	($55)	$86	($224)	$86	($224)
MI	J H Campbell	84	170	89	180	70	140	$206	($494)	$233	($527)	$289	($331)
MI	St. Clair	64	130	78	160	76	160	$88	($482)	$21	($629)	$6	($664)
MI	Trenton Channel	62	130	58	120	56	110	($156)	($736)	($147)	($647)	($102)	($592)
MO	Labadie	150	300	160	330	140	290	$67	($1,233)	$130	($1,270)	$352	($848)
MO	Meramec	62	120	62	130	57	110	($116)	($606)	($106)	($586)	($13)	($493)
MO	New Madrid Power Plant	36	73	37	76	39	79	$233	($77)	$273	($47)	$288	($52)
MO	Rush Island	67	140	62	130	66	130	$29	($511)	$71	($419)	$137	($413)
MO	Sibley	12	26	13	29	14	30	$113	$3	$107	($23)	$89	($51)
MO	Thomas Hill Energy Center	18	39	21	46	24	51	$392	$212	$397	$197	$480	$260
MT	Colstrip	28	63	29	65	23	53	$766	$476	$1,037	$737	$882	$632
NC	H F Lee Steam Electric Plant	25	51	30	62	19	39	($51)	($261)	($42)	($307)	($58)	($228)
NC	L V Sutton	31	64	33	69	24	48	($55)	($325)	($49)	($348)	($75)	($275)
ND	Antelope Valley	44	98	44	100	41	92	$100	($360)	$82	($378)	$78	($342)
ND	Coal Creek	82	180	56	130	48	110	($74)	($894)	$149	($381)	$269	($221)
NE	Gerald Gentleman Station	34	78	32	72	31	71	$441	$71	$429	$89	$1,120	$790
OH	Eastlake	120	240	120	230	120	240	($493)	($1,513)	($382)	($1,312)	($375)	($1,395)
OH	Gen J M Gavin	62	120	60	120	78	160	$1,206	$726	$1,226	$726	$996	$346
OH	W H Zimmer Generating Station	41	83	57	120	54	110	$315	($35)	$407	($73)	$161	($289)
OK	Grand River Dam Authority	53	110	50	110	57	120	$35	($455)	$55	($405)	$63	($457)
OK	Northeastern	65	140	52	110	53	110	($23)	($583)	$123	($357)	$240	($250)
PA	Bruce Mansfield	47	95	58	120	57	110	$1,279	$879	$1,383	$893	$1,423	$943
SC	Canadys Steam	25	52	31	64	37	75	($117)	($337)	($144)	($414)	($162)	($482)
TN	Gallatin	47	94	48	97	55	110	$172	($218)	$178	($222)	$216	($254)
TN	Johnsonville	74	150	94	190	85	170	($232)	($812)	($237)	($1,057)	($269)	($969)
TX	Big Brown	82	180	95	198	94	200	$81	($739)	$79	($776)	($54)	($974)
TX	Harrington Station	22	50	20	47	15	34	$558	$318	$450	$226	$408	$248
TX	Limestone	37	79	38	84	44	94	$879	$529	$877	$495	$878	$458
TX	Martin Lake	110	230	111	230	100	220	$813	($217)	$729	($259)	$777	($183)
TX	Monticello	87	190	88	196	86	190	$777	($103)	$526	($371)	$435	($355)
TX	Tolk Station	23	52	25	55	20	46	$524	$284	$515	$266	$548	$338
TX	W A Parish	70	160	78	177	81	180	$1,291	$571	$986	$165	$980	$150
VA	Yorktown Power Station	46	91	39	79	34	68	($208)	($588)	($161)	($493)	($156)	($446)
WI	Nelson Dewey	32	66	34	70	29	61	($160)	($440)	($164)	($464)	($132)	($392)
WV	Kammer	48	98	40	83	48	98	($275)	($695)	($218)	($578)	($260)	($670)
WV	Phil Sporn	40	81	42	83	27	53	($174)	($504)	($166)	($506)	($102)	($322)
Totals (Rounded)		**2,800**	**5,700**	**2,900**	**6,000**	**2,700**	**5,700**	**$9,586**	**($15,284)**	**$10,561**	**($14,944)**	**$11,162**	**($13,408)**

Appendix B – Statement of Dr. Jonathan Levy

Methodology for health externality calculations from power plants

March 8, 2012

EIP asked me to estimate health impacts from the fine particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2), and nitrogen oxide (NO_x) emissions at 52 coal fired power plants across the country for 2009, 2010, and 2011, using emissions data supplied to me by EIP.

For the estimates of health damages per ton of emissions from a number of power plants in the United States, the core methodology was based on Levy et al. (2009), with some modifications to reflect updates since the time of that analysis. Please refer to the full manuscript for more extensive detail regarding the methods.

Briefly, the original analysis in Levy et al. (2009) focused on mortality risks from fine particulate matter ($PM_{2.5}$) from 407 coal-fired power plants across the United States. This study used standard methods for health externality assessment, similar to the approach used by US EPA when modeling the health benefits of environmental regulations. This included estimating emissions from each power plant, applying atmospheric dispersion models to determine how those emissions influence air pollution levels, and using epidemiological evidence to determine a concentration-response function and calculate the public health burden associated with those air pollution levels. Dollar values can be assigned to health outcomes, focusing in this case on premature mortality. The study focused on $PM_{2.5}$ concentrations and the influence of both primary $PM_{2.5}$ emissions and pollutants that can form $PM_{2.5}$ through secondary reactions (SO_2 and NO_2). Because atmospheric chemistry and the shape of the concentration-response function are relatively insensitive to the contribution from an individual power plant, the per-ton damage values can be applied to a range of estimated emissions from a given power plant.

The effect of emissions from each individual power plant on $PM_{2.5}$ concentrations was estimated using a county-resolution source-receptor matrix. While simplified relative to state-of-the-science atmospheric dispersion models, prior analyses have shown that health risk estimates were similar using this model and more complex models, and plant-specific estimates for 407 power plants would be computationally challenging using models such as CMAQ. In Levy et al. (2009), health evidence was taken from a recent publication from the Harvard Six Cities Study (Schwartz et al. 2008), which looked directly at whether the effect of $PM_{2.5}$ on mortality differed based on ambient concentrations (i.e., whether there was a threshold or other non-linearity). Levy et al. therefore used functions in which the concentration-response function varied across the range of ambient concentrations, to account for the possibility of thresholds or other non-linearities. A value of statistical life approach was applied to monetize mortality damages.

For the current application, the methodology was updated in a few key ways. First, population numbers were updated using 2010 Census data by county, as the Levy et al. (2009) publication used 2000 Census data. Similarly, the per capita mortality rate data were updated to reflect more recent data available from CDC, using 2003-2007 rates rather than 1999-2003 rates. In addition, to give a broader characterization of uncertainty related to choice of epidemiological study, externalities were calculated using both the function derived from Schwartz et al. (2008) and an alternative function derived from the American Cancer Society cohort study (Krewski et al. 2009). This approach illustrates the range of estimates across health studies. Of note, these two cohort studies are most typically used by EPA in their regulatory estimates, with central estimates between the values from the two studies, so this provides a bounding calculation for the health risks. Finally, Levy et al. (2009) used a value of statistical life of $6 million in 1999 dollars. To update the calculation to current dollars, the most recent EPA estimate of $7.4 million in 2006 dollars was used as a starting point (http://yosemite.epa.gov/ee/epa/eed.nsf/pages/MortalityRiskValuation.html). Adjusting to 2012 dollars resulted in a value of statistical life of $8.3 million.

All values reported reflect central estimates, using direct outputs from the source-receptor matrix, central estimates from each of the concentration-response functions, and $8.3 million as a value of statistical life.

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EDUCATION

BACHELOR OF ARTS in Applied Mathematics, Harvard College, 1993

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RESEARCH FELLOW in Environmental Health and Biostatistics, Harvard School of Public Health, 1999-2001

EXPERIENCE

2010-present Professor, Dept of Environmental Health, Boston University School of Public Health
2006-2010 Associate Professor, Dept of Environmental Health, Harvard School of Public Health
2001-2006 Assistant Professor, Dept of Environmental Health, Harvard School of Public Health
1993-1996 Associate Consultant, Pizzano and Company, Stoneham, MA

Major Professional Service:
2011- Member, NRC Committee on Science for EPA's Future
2010- Editorial Board, Environmental Health
2010-2011 Section Editor, Health and the Environment, BMC Public Health
2009- Advisory Council on Clean Air Compliance Analysis, U.S. EPA
2009-2011 Member, NRC/IOM Committee to Develop Framework and Guidance for Health Impact Assessment
2009 Board of Scientific Counselors, Clean Air Subcommittee, U.S. EPA
2006-2008 Member, NRC Committee on Improving Risk Analysis Methods Used By the U.S. EPA
2004-2008 Section Editor, Chapter on Environmental/Occupational Health, Encyclopedia of Public Health
2004-2006 Member, NRC Committee on the Effects of Changes in New Source Review Programs for Stationary Sources of Air Pollution

Honors and Awards:
2010 Finalist, Onassis Prize for the Protection of the Environment
2009 Knowles Scholar, Harvard College
2008 FAA Centers of Excellence Faculty of the Year Award
2005 Health Effects Institute, Walter A. Rosenblith New Investigator Award
2002-2010 HSPH, Commendation for High Student Evaluations (8 times)
1999 Howard Raiffa Student Achievement Award

1997-1998 Air and Waste Management Association Scholar, First Place
1992-1993 Phi Beta Kappa, Harvard College branch

Publications (selected from 105 peer-reviewed publications):

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Research Support (Selected, as PI/co-PI):

Ongoing

2010-2014 Effects-Based Cumulative Risk Assessment in a Low-Income Community near a Superfund Site (US EPA, RD83457701)

2010-2013 Health Impacts of Aviation-Related Air Pollutants Phase III (FAA, Coop Agreement No. 10-C-NE-BU-001)

2011-2012 Health Effects of Aviation-Related Noise on the Elderly (FAA, Coop. Agreement No. 10-C-NE-BU-002)

2012-2012 An Open-Source Model of the Environmental and Health Benefits of Interventions on the PJM Interconnection (Heinz Foundation, C2988)

Completed

2009-2011 A Discrete Event Simulation Model of Environmental Exposures and Pediatric Asthma (NIEHS, 1R21ES017522)

2007-2011 Health Impacts of Aviation-Related Air Pollutants Phase I and II (FAA, Coop. Agreement No. 07-C-NE-HU/09-C-NE-HU)

2010-2011 Risk-Based Prioritization Among Air Pollution Control Strategies in Yangtze River Delta, China (Energy Foundation)

2005-2010 Air Pollution and Health Risks from Port City Emissions (Gilbert and Ildiko Butler Foundation)

2009-2009 The Magnitude and Distribution of Air Pollution Health Impacts in Yangtze River Delta, China (Energy Foundation)

2007-2008 The Influence of Traffic on Air Quality in Brigham Circle: A Community-University Partnership (City of Boston, TAQ 22860)

2005-2008 Using Geographic Information Systems to Evaluate Heterogeneity in Indoor and Outdoor Concentrations of Particle Constituents (Health Effects Institute, 4727-RFA04-5/05-1)

2005-2007 Predictors of Spatial Patterns of Urban Air Pollution (NIH/NIEHS, R03 ES013988-01)

2003-2007 Integrating Equity into Benefit-Cost Analysis: Theory and Practice (NSF, SES-0324746)

2006-2006 Health Costs and Benefits of Enhanced Residential Insulation in the United States (NAIMA)

2005-2005 Assessing Global Warming Emission Reduction Impacts of Increased Insulation in New and Existing Homes (NAIMA)

2003-2004 Meta-Analysis of Ozone Mortality Studies (US EPA, 3D-6865-NTEX)

2002-2003 Comprehensive Evaluation of the Public Health Benefits of Increased Residential Insulation (NAIMA)

1993-2003 Health Impact Analysis in Air Pollution Control Strategies (Pew Charitable Trusts)