Death, Disease & Dirty Power

Mortality and Health Damage Due to Air Pollution from Power Plants

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This report and the full Abt Associates report, *The Particulate-Related Health Benefits of Reducing Power Plant Emissions* (October 2000), are available at the Clear the Air website:

www.cleartheair.org

Credits:

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Foreword

John D. Spengler, *Professor of Environmental Health, Harvard School of Public Health (Boston, September 2000)*

On December 5, 1952, the residents of London, England awoke to the dawn of a five-day reign of death. A temperature inversion had trapped the coal smoke from the city's furnaces, fireplaces, and industrial smokestacks, creating a "killer fog" that hovered near the ground. People began to die from respiratory and cardiopulmonary failure. Not until the weather system that had trapped London's pollution finally loosened its grip and the soot-filled air cleared out did death rates return to normal. The end of the episode saw more than three thousand dead; a five-fold increase over the normal death rate.

While incidents like London's "killer fog" of 1952 clearly demonstrate a link between air pollution and death, only in the past decade have tremendous advances in medical science and epidemiology allowed researchers to quantify the health impacts of everyday air pollution levels. In studies conducted in cities throughout the world, epidemiologists have consistently found that more people are hospitalized and die from respiratory and cardiac failure in proportion to elevated levels of soot, or "fine particles," and other pollutants. The consistent worldwide findings, combined with a much clearer understanding about how we are exposed to outdoor air pollution, have convinced most experts that these results are not a coincidence. In particular, two landmark studies established that people living in more polluted areas suffer a higher risk of death from fine particle pollution than those living in less polluted areas.

These studies and many others formed the basis of U.S. EPA's 1997 decision to issue a new national ambient air quality standard for "fine particles" known as $PM_{2.5}$ and defined as particles smaller than 2.5 microns—one millionth of a meter in diameter (less than one-hundredth of the width of a human hair). EPA estimated that attaining the annual fine particle levels required by the new standard would prevent 15,000 deaths per year. And recent monitoring data suggests that if present air pollution levels persist, the health standard EPA established will be violated every year in hundreds of communities in the U.S. What is more, as EPA acknowledged, the science underlying the standard indicates that deaths occur even at levels below the standard. Indeed, the science now tells us that health effects extend to lower levels of fine particles in our air, suggesting there is no definite threshold below which the air is safe to breathe.

Not surprisingly, industries that contribute to this air pollution, such as the electric utility industry and diesel trucking industry, are disputing EPA's decision and the science on which it was based. They claim EPA relied on "junk science" and then sued in court to block the standards. They demanded access to the data underlying the seminal studies to help refute the results. In the end, the Health Effects Institute, a research center co-funded by industry and EPA and founded to be a neutral arbiter for policy-related health science disputes, was called upon to reanalyze the studies.

This past summer, HEI announced the results of its reanalysis, which unequivocally confirmed the findings of the two major studies underlying the fine particle standard. HEI also released a new study that further supports the link between particles and death. And while the fate of the fine particle standard itself awaits resolution in the courts, there is no longer any legitimate doubt that fine particles at levels commonly experienced in many parts of the U.S. contribute significantly to death and disease.

Most of the coal used in this country today is burned by aging power plants for the production of electricity. In a variety of contexts, researchers have sought to quantify the contribution to fine particle health impacts made by these plants. Health researchers have employed some assessment methods to estimate the relative contribution of power plants to total deaths. EPA's Regulatory Impact Analysis for the $PM_{2.5}$ National Ambient Air Quality Standard ("NAAQS") examined the contribution of power plant emissions to fine particle concentrations in our air. In addition, EPA's cost-benefit analyses of the Clean Air Act included the benefits

associated with expected reductions in power plant-generated fine particle pollution, providing strong justification for the emission control costs imposed by the Act. More recently, in a study of two coal-fired power plants in Massachusetts, my Harvard School of Public Health colleague Jonathan Levy and I found that fine particle pollution from these two plants alone is associated with over 100 deaths annually.

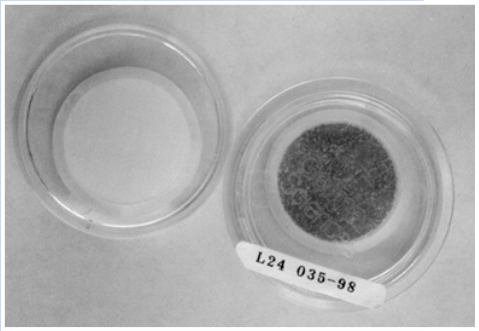
Now, employing the same analytic tools used by the U.S. EPA in a variety of policy-setting and regulatory decisionmaking contexts, Abt Associates has provided the most rigorous look to date at the contribution of air emissions from the nation's power plants to fine particle levels and the impact of those emissions on human health. Abt Associates' work builds on methods used by the U.S. EPA in developing important air quality standards and assessing its air regulatory programs. Abt Associates finds that power plant pollution contributes to several thousand deaths each year. In short, these findings imply that our regulatory strategies and priorities should be reconsidered. A variety of policies could help lower the risks posed by power plant pollution — from broader application of existing pollution control technologies, to use of cleaner fossil fuels, to ultimate replacement of the existing energy infrastructure with more sustainable means of producing electricity. We can only hope the information provided through this study will help crystallize the policy debate around the need for actions to reduce the health risks posed by the pollution produced by our current energy system.

The Abt Associates approach enables us to combine information from many well-done studies to derive a quantitative relationship between air pollution and health effects. These studies tell us that the concept of a threshold demarcating safe from unhealthy air is now outdated. They provide continuous damage functions that lead us to expect benefits from deeper and deeper reductions in air pollution. The insight derived from this new analytical approach provides important information to the benefit side of the cost-benefit debate. The debate over the policy consequences of this shift in thinking may be difficult and acrimonious in the near term as power companies, regulators, lawmakers, and citizens adjust to new concepts of incorporating health damage costs into control strategies, weigh local impacts versus regional damage, and consider the appropriateness of emission reduction trading among pollution sources. The primary advantage of a quantitative method to assess air pollution effects with no threshold is that it represents more accurately the biological reality. The old threshold concept appears even more outmoded when we consider the notion of "safe" levels for each of the hundreds of contaminants in the air. We will all benefit from this emerging methodology that brings air pollution health research into the public decisionmaking process. All of us, throughout our lives, are susceptible to the adverse effects of air pollution. Now, our health interests can be more directly incorporated into the debate over our energy, environmental, and economic future.

All of us, throughout our lives, are susceptible to the effects of air pollution.

What are Fine Particles?

Fine particles are a mixture of a variety of different compounds and pollutants that originate primarily from combustion sources such as power plants, diesel trucks and buses, cars, etc. They are sometimes referred to as $PM_{2.5}$ (particulate matter smaller than 2.5 microns in diameter — less than one-hundredth of the width of a human hair). Fine particles are either emitted directly from these combustion sources or are formed in the atmosphere through complex oxidation reactions involving gases, such as sulfur dioxide (SO_2) or nitrogen oxides (NO_X). Among particles, fine particles are of gravest concern because they are so tiny that they can be inhaled deeply, thus evading the human lungs' natural defenses.



Fine particle filters: clean and exposed 24 hours.

Executive Summary

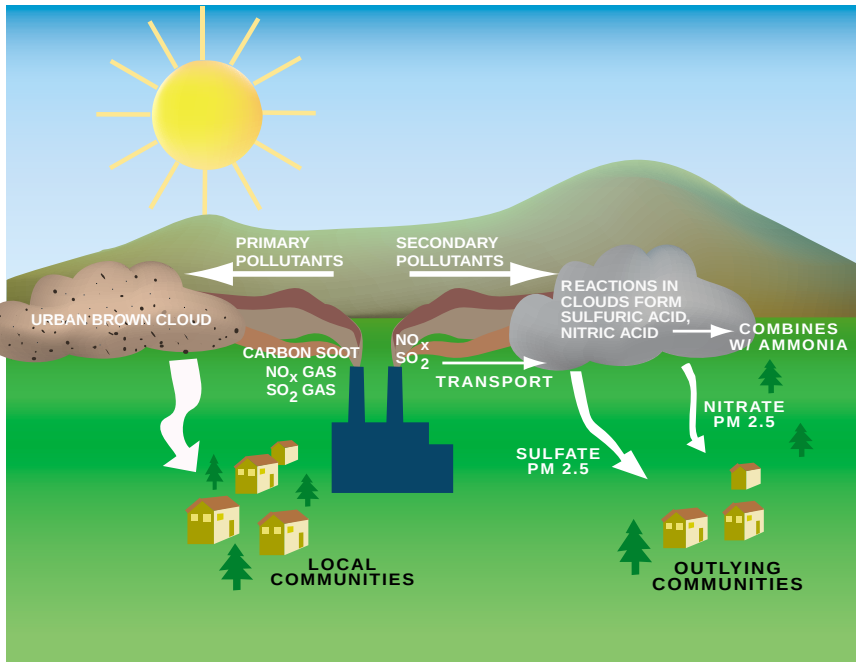
The Clean Air Task Force, on behalf of the Clear the Air campaign, commissioned Abt Associates to quantify the health impacts of fine particle air pollution, commonly known as soot, from power plants, as well as the expected benefits (avoidable deaths, hospitalizations, etc.) of policies that would reduce fine particle pollution from power plants. The health effects analyzed include death, hospitalizations, emergency room visits, asthma attacks, and a variety of lesser respiratory symptoms.

This report summarizes the findings of the Abt Associates study, reviews the contribution of power plants to fine particle pollution, and discusses policies that will reduce power plant fine particle pollution and thus save thousands of lives. Key findings include:

- Fine particle pollution from U.S. power plants cuts short the lives of over 30,000 people each year.
- In more polluted areas, fine particle pollution can shave several years off its victims' lives.
- Hundreds of thousands of Americans suffer from asthma attacks, cardiac problems and upper and lower respiratory problems associated with fine particles from power plants.
- The elderly, children, and those with respiratory disease are most severely impacted by fine particle pollution from power plants.
- Metropolitan areas with large populations near coal-fired power plants feel their impacts most acutely – their attributable death rates are much higher than in areas with few or no coal-fired power plants.
- Power plants outstrip all other polluters as the largest source of sulfates – the major component of fine particle pollution – in the U.S.
- Approximately two-thirds (over 18,000) of the deaths due to fine particle pollution from power plants could be avoided by implementing policies that cut power plant sulfur dioxide and nitrogen oxide pollution 75 percent below 1997 emission levels.

Fine particle pollution is responsible for increased risk of death and shortened life spans. Abt Associates' findings are based on a body of well-accepted scientific work on the health effects of fine particle pollution. The discussion at pages 12-16 of the report contains an extensive review of the scientific studies used by Abt Associates linking fine particle pollution to death and

Power Plant Particle Formation



FJ VENTRE

Fine particles are emitted directly or formed in the atmosphere through complex reactions.

other health damages. The methodology of how the Abt Associates analysis was performed is discussed at pages 16-17 of this report.

Recommendations

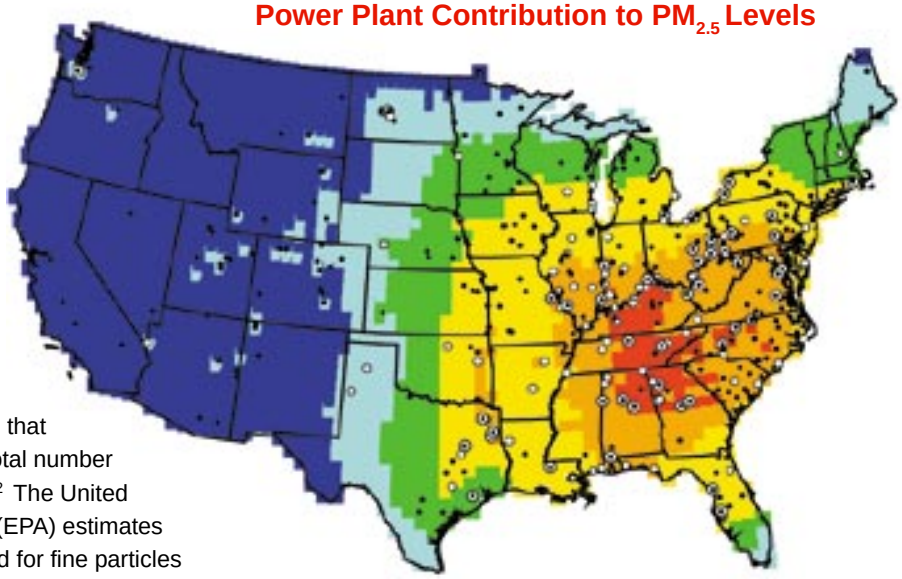
For over thirty years the oldest, dirtiest coal-burning power plants have circumvented the most protective air emissions standards required of modern plants. As a result, these so-called "grandfathered" power plants are permitted to emit as much as 10 times more nitrogen oxides and sulfur dioxide than modern coal plants. Polluting coal-fired power plants must be made to comply with modern emissions control standards. In addition, the nation's power fleet should be held to stringent caps on all four of the key power plant pollutants including nitrogen oxides, sulfur dioxide, mercury and carbon dioxide. The deaths, hospitalizations and lost work time caused by fine particles from power plants can be reduced comprehensively only when the Clean Air Act's 30-year loophole for old, dirty power plants is finally closed. Requirements such as these can ensure that U.S. energy policy better accounts for the public health and environmental costs associated with electricity production and will propel us toward a more sustainable energy future that relies increasingly on renewable energy resources and conservation.

New Findings

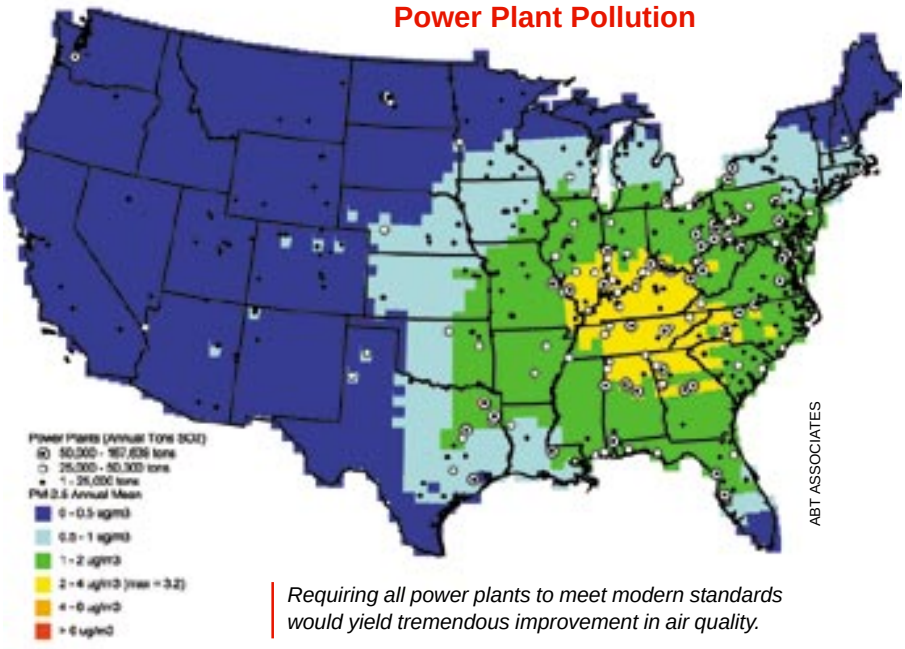
Numerous studies over the years have linked fine particles to a variety of health damages, from increased asthma attacks to hospital visits to death. Researchers estimate that as many as 60,000 people die prematurely each year because of exposure to fine particles.[1] And some researchers believe that this figure may even underestimate the total number of deaths due to fine particles in the U.S.[2] The United States Environmental Protection Agency (EPA) estimates that attainment of the new health standard for fine particles alone could save 15,000 lives each year.[3] However, to date there has been no definitive study quantifying the deaths and other health effects attributable solely to fine particles from power plant pollution.

Now, for the first time, this report reveals the power industry's staggering share of the toll of death and disease from fine particles in our air. Using peer-reviewed, state-of-the-art research methodology, Abt Associates finds over 30,000 deaths each year are attributable to fine particle pollution from U.S. power plants. The underlying research shows that these people are dying months or years earlier because of power plant air pollution. Further, the study finds that by requiring the nation's

Power Plant Contribution to $PM_{2.5}$ Levels



...and with 75% Reduction in Power Plant Pollution



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Requiring all power plants to meet modern standards would yield tremendous improvement in air quality.

fleet of older, dirty power plants to cut their sulfur dioxide and nitrogen oxide emissions by 75 percent, consistent with current legislative proposals,[4] approximately two-thirds (over 18,000) of these deaths could be avoided.[5]

The deaths from power plant pollution exceed the death toll from other causes commonly understood to be major public policy priorities. For instance, drunk driving causes nearly 16,000 deaths per year.[6] There are over 17,000 homicides in the U.S. each year.[7] Moreover, the 18,000 deaths that could be avoided by cleaning up the nation's power plants are three times the number of automobile fatalities avoided each year through the use of safety belts.[8] Among air pollution sources, the deaths attributable to power plants are rivaled only by those due to the fine particle pollution from the combined total of all the diesel trucks, buses, locomotives, and construction equipment in the U.S. which, according to the Abt Associates analysis, are responsible for approximately 80 percent of the deaths attributable to power plants.

The Abt Associates report further shows that hundreds of thousands of Americans suffer from asthma attacks, cardiac problems and upper and lower respiratory ailments associated with fine particles from power plants. These health damages result in thousands of respiratory and cardiopulmonary-related hospitalizations and emergency room visits as well as hundreds of thousands of lost work and school days, many of which could be avoided by cleaning up older power plants. For instance, the study finds that power plant particle pollution causes more than 603,000 asthma attacks per year, 366,000 of which could be avoided by cleaning up power plants to modern standards.

Respiratory distress severe enough to require a trip to the emergency room can be a terrifying experience for patients and their families. Victims of asthma attacks say that during an attack they wonder if and when their next breath will come. In addition to these serious physical and emotional costs, air pollution also wracks up large monetary costs. Emergency room and hospital treatment costs can cripple a family financially. The average hospital stay for a respiratory ailment lasts about a week.[9] Bouts of respiratory illness and asthma attacks mean lost workdays for workers and lost productivity for their employers. And, although priceless, in a variety of contexts we place a monetary value on the loss of human life. Using accepted valuation methodology employed by EPA in its regulatory impact analyses, Abt Associates finds that the total monetary benefits of cleaning up power plants to modern pollution standards would be over $100 billion per year.

National Power Plant Health Impacts

Health Effect	Study	Incidence (cases/year) Avoided by 75% Power Plant Reduction	Incidence (cases/year) Power Plant Total
Mortality	HEI, 2000 Pope Reanalysis (Annual mean, All Cause)	18,700	30,100
All Respiratory and Cardiovascular Hospitalizations	Pooled COPD+Respiratory+ Asthma+CardioVascular	12,200	20,100
Asthma-Related Emergency Room Visits	Schwartz et al., 1993	4,320	7,160
Chronic Bronchitis	Pooled	11,400	18,600
Asthma Attacks	Whittemore and Korn, 1980	366,000	603,000
Lost Work Days	Ostro, 1987 - WLDs	3,190,000	5,130,000
Minor Restricted Activity Days	Ostro and Rothschild, 1989	16,400,000	26,300,000

By modeling the impact of power plant pollution throughout the lower 48 states, Abt Associates developed health impact estimates for every state and major metropolitan area. Not surprisingly, states with large populations in close proximity to many coal-fired power plants fared the worst.

States: Health Impacts

	State	Mortality	Total Hospital-izations	Asthma Attacks
1	Pennsylvania	2,250	1,510	38,400
2	Ohio	1,920	1,250	37,100
3	New York	1,870	1,260	37,000
4	North Carolina	1,800	1,200	37,100
5	Florida	1,740	1,350	30,800
6	Illinois	1,700	1,110	33,100
7	Georgia	1,630	1,050	38,200
8	Tennessee	1,440	910	27,100
9	Texas	1,310	885	31,700
10	Virginia	1,240	823	27,900
11	Alabama	1,110	701	20,600
12	New Jersey	1,100	758	21,900
13	Indiana	1,030	679	20,500
14	Kentucky	997	635	19,000
15	Maryland	927	608	20,900

...and Avoided by a 75% Reduction

	State	Mortality	Total Hospital-izations	Asthma Attacks
1	Pennsylvania	1,460	947	24,200
2	New York	1,200	792	23,200
3	Ohio	1,200	768	22,800
4	North Carolina	1,190	771	24,000
5	Georgia	1,090	688	25,200
6	Florida	1,050	760	17,300
7	Illinois	981	635	19,000
8	Tennessee	857	533	15,900
9	Virginia	828	542	18,400
10	Texas	805	534	19,100
11	Alabama	738	459	13,500
12	New Jersey	718	481	13,900
13	Maryland	619	397	13,700
14	Indiana	585	379	11,500
15	Kentucky	578	360	10,900

Conversely, states with large populations but without coal-fired plants fared much better. For example, California, which has the nation's largest population and some of its worst air quality, has very few coal or oil-fired power plants. Abt Associates estimates that only 259 deaths are attributable to power plant pollution in California and the state ranked almost *last* in per capita impact (1.4 deaths per 100,000 adults). Kentucky, the state with the highest reliance on coal for production of electricity ranked first in related per capita mortality at more than 44 deaths per 100,000 adults, *over 30 times higher* than California's per capita mortality rate.

Note — For complete tables, see Appendix.

States: Per Capita Deaths

	State	Total Power Plant Deaths	Avoided by 75% Reduction	Deaths per 100,000 adults
1	Kentucky	997	578	44.1
2	West Virginia	459	296	43.3
3	Alabama	1,110	738	42.8
4	Tennessee	1,440	857	42.3
5	District of Columbia	118	80	41.3
6	North Carolina	1,800	1,190	38.6
7	South Carolina	791	515	36.0
8	Georgia	1,630	1,090	35.5
9	Mississippi	489	318	32.2
10	Pennsylvania	2,250	1,460	32.0
11	Arkansas	479	277	30.7
12	Virginia	1,240	828	30.3
13	Indiana	1,030	585	30.0
14	Ohio	1,920	1,200	29.7
15	Maryland	927	619	28.8
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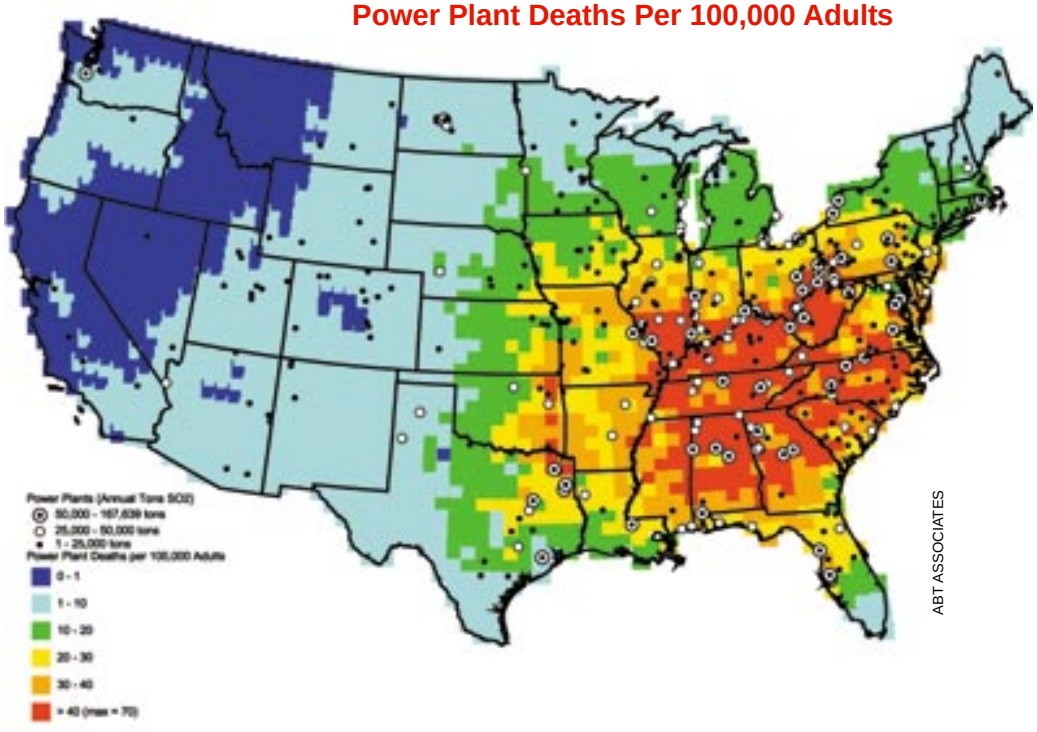
46	California	259	49	1.4

Similarly, metropolitan areas with large populations near coal-fired power plants feel their impacts most acutely. In large metropolitan areas, many hundreds of lives are shortened each year.

States in "coal country" suffer the greatest per capita impacts.

Power Plant Deaths Per 100,000 Adults



Metro Areas: Health Impacts

	Metropolitan Statistical Area	Mortality	Total Hospital-izations	Asthma Attacks
1	New York, NY	2,290	1,580	46,200
2	Washington, DC	1,140	764	28,600
3	Philadelphia, PA	997	654	19,000
4	Chicago, IL	995	648	21,400
5	Atlanta, GA	647	432	18,700
6	Pittsburgh, PA	585	395	9,210
7	Detroit, MI	527	343	11,200
8	St. Louis, MO	494	309	9,200
9	Tampa, FL	494	409	8,070
10	Boston, MA	454	320	9,540
11	Akron, OH	442	293	8,170
12	Cincinnati, OH	377	248	7,870
13	Dallas, TX	369	247	10,500
14	Greensboro, NC	309	210	6,380
15	Charlotte, NC	298	201	6,780
16	Nashville, TN	260	167	5,800
17	Birmingham, AL	257	164	4,760
18	Louisville, KY	256	162	4,870
19	Indianapolis, IN	250	161	5,300
20	Greenville, SC	226	148	4,520

...and Avoided by a 75% Reduction

	Metropolitan Statistical Area	Mortality	Total Hospital-izations	Asthma Attacks
1	New York, NY	1,470	991	29,000
2	Washington, DC	762	501	18,800
3	Philadelphia, PA	647	406	11,700
4	Chicago, IL	572	368	12,200
5	Atlanta, GA	431	283	12,300
6	Pittsburgh, PA	371	241	5,620
7	Detroit, MI	322	207	6,740
8	Tampa, FL	291	211	4,040
9	Boston, MA	287	198	5,880
10	Akron, OH	283	185	5,160
11	St. Louis, MO	280	170	5,060
12	Dallas, TX	228	151	6,390
13	Cincinnati, OH	223	144	4,590
14	Greensboro, NC	207	137	4,180
15	Charlotte, NC	191	125	4,240
16	Birmingham, AL	174	109	3,170
17	Norfolk, VA	150	97	3,750
18	Nashville, TN	149	95	3,300
19	Greenville, SC	145	93	2,860
20	Indianapolis, IN	145	91	3,000

However, much smaller metropolitan areas in and around “coal country” suffer the greatest per capita impacts, such as Chattanooga, Tennessee; Gadsden, Alabama; Terre Haute, Indiana; Wheeling, West Virginia; and Owensboro, Kentucky. Their death rates are much higher, for example, than that of New York City. Compare Chattanooga at 49.3 deaths per 100,000 adults with New York at 19.3 per 100,000.

In fact, because these health effects estimates include only the effects from airborne fine particles, they significantly understate the total adverse impact on public health from power plants. Excluded from these estimates are the health effects from other power plant pollutants, such as air emissions that result in ozone smog, air toxics, global warming, and the impacts from the consumption of fish contaminated by power plant mercury emissions.

Note — Complete state and metropolitan area tables are included in the Abt Associates report.

The full Abt Associates report is available at the Clear the Air website

www.cleartheair.org

Power plants are significant contributors to fine particle levels in vast areas of the United States.

Metro Areas: Per Capita Deaths

	Metropolitan Statistical Area	Total Power Plant Deaths	Avoided by 75% Reduction	Deaths per 100,000 adults
1	Gadsden, AL	41	27	59.0
2	Chattanooga, TN	154	100	49.3
3	Anniston, AL	37	25	49.0
4	Florence, AL	43	27	48.2
5	Johnson City, TN	154	93	48.0
6	Asheville, NC	69	44	46.9
7	Terre Haute, IN	44	25	46.8
8	Cumberland, MD	33	22	46.5
9	Birmingham, AL	257	174	46.0
10	Danville, VA	35	24	45.6
11	Owensboro, KY	24	12	45.0
12	Knoxville, TN	190	114	44.5
13	Wheeling, WV	46	30	44.5
14	Huntington, WV	86	55	44.0
15	Charleston, WV	69	44	43.3
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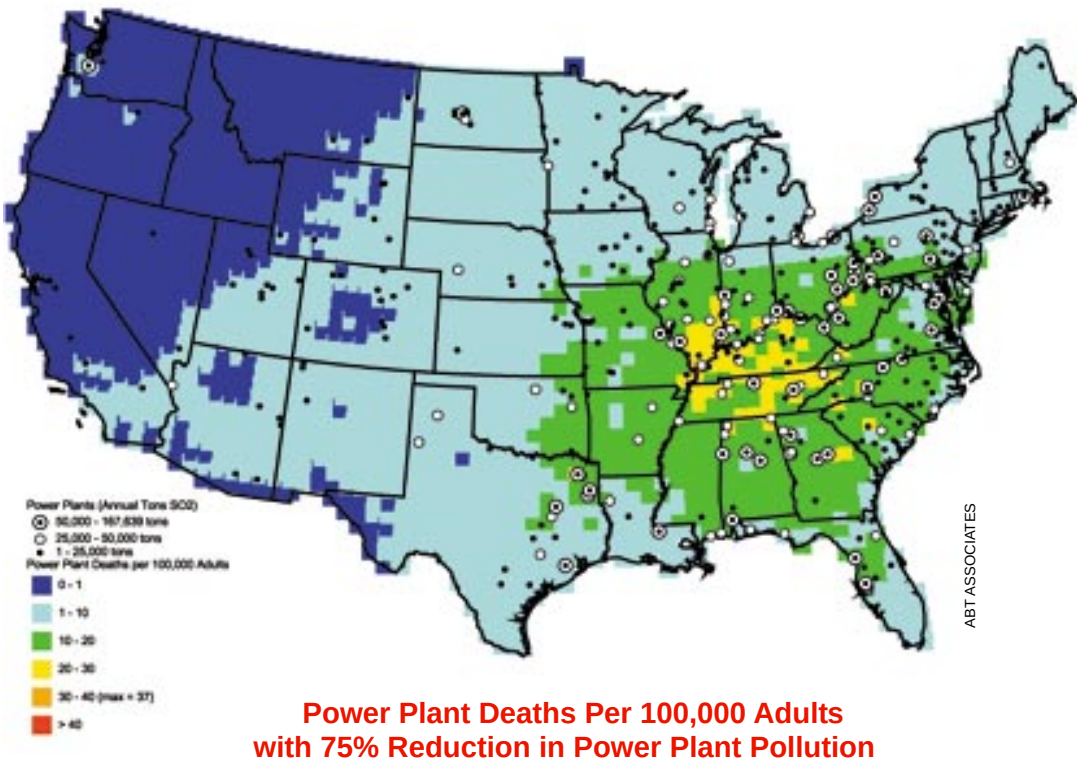
138	New York, NY	2,290	1,470	19.3



Power Plant Deaths Per 100,000 Adults with 75% Reduction in Power Plant Pollution

Children, the Elderly, and People with Respiratory Disease Face the Greatest Risk

While all of us are at risk from exposure to fine particles, the elderly, people with respiratory disease, and children are at greatest risk. Young children need to be healthy to play, to learn, and to grow into strong adults. School age kids find participating in sports and even studying difficult when battling respiratory problems. Studies estimate that tens of thousands of elderly people die each year from exposure to ambient levels of fine particles. Fine particles are also associated with tens of thousands of hospital admissions annually. Many of these hospital admissions involve elderly people already suffering from lung or heart disease. Respiratory ailments can rob the elderly of the full enjoyment of their sunset years. Breathing fine particles can also hurt individuals of any age with heart disease, emphysema, and chronic bronchitis by forcing them to require additional medical treatment. People struggling with these ailments try to cope by limiting their exposure to respiratory irritants in their environment, but they cannot control the quality of the outdoor air they breathe.

Children at Risk

Children are at special risk: they breathe 50 percent more air per pound of body weight than adults do. Because children's respiratory systems are still developing, they generally are more susceptible to environmental threats than healthy adults. Damage caused by air pollution can mean they never reach their potential lung development. Exposure to fine particles is associated with increased frequency of childhood illnesses, which are of concern both in the short run, and for the future development of healthy lungs in the affected children. Babies and young children are especially susceptible to fine particles.

A recent study found a 26 percent increased risk for Sudden Infant Death Syndrome (SIDS) in cities with high levels of particulate pollution.[10] Moreover, infants in high pollution areas were 40 percent more likely to die of respiratory causes.[11] Particles are also associated with increased respiratory symptoms and reduced lung function in children, including symptoms such as aggravated coughing and difficulty or pain in breathing. These can result in school absences and limitations in normal childhood activities.

Breathing fine particles aggravates asthma symptoms and while children make up 25 percent of the population, they comprise 40 percent of all asthma cases.[12] Asthmatic children who breathe fine particles use more medication, receive more medical treatment, and visit the hospital more often.

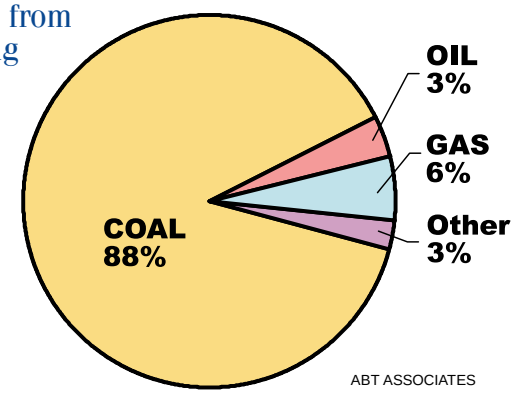
Coal-burning Power Plants: #1 Source

The link between power plants and fine particles is clear. In most areas of the country, sulfate — acidic fine particles — dominate the total mass of fine particle pollution measured at monitors located throughout the United States. And power plants outstrip all other polluters as the largest source of sulfate air pollution in the U.S.[13] In 1998, power plants were responsible for 67 percent—a full two thirds—of the annual total sulfur dioxide (SO_2) and over a quarter of the nitrogen oxides (NO_X) emitted in the U.S.;[14] over 13 million tons of SO_2 and over six million tons of NO_X.[15] Sulfur dioxide and NO_X gas emissions from power plants form fine particles as they chemically convert in the atmosphere to form fine sulfate and nitrate particles. Power plants also emit fine carbon soot particles directly from their smokestacks, which may appear as a black plume leaving the stack. In 1999, power plants directly emitted nearly 300,000 tons of fine carbon soot particles.[16]

While the 1990 Clean Air Act Acid Rain Program (Title IV) had resulted in significant initial progress in reducing SO_2 emissions from power plants, those emissions have recently begun to rise. The National Emissions Trends Report shows that power plant SO_2 emissions crept upward every year since 1995, rising more than 10 percent.[17] Disturbingly, in 1998, power plants emitted 1.26 million more tons of SO_2 than they emitted in 1995.[18] Nitrogen oxide emissions from power plants have risen 44 percent since 1970.[19] Moreover, power plant NO_X, PM_{10}, and volatile organic emissions—all of which contribute to fine particle levels — have also crept up slightly over the past few years according to the 1998 EPA report.[20] Taken together, while these increases are not enormous, the data suggest poor progress in curbing power plant emissions.

Indeed, the largest share of power plant-derived fine particle pollution comes not from direct emissions but instead from the conversion of SO_2 and NO_X into fine particle sulfate and nitrate.[21] This impact is most pronounced in the mid-western United States – an area densely populated with coal-burning power plants – and in the eastern United States – areas downwind of the vast majority of the nation's coal-burning power plants.

Most of the sulfur dioxide pollution from power plants comes from burning coal.



ABT ASSOCIATES

PETER ALTMAN

Even before London's "killer fog" event, coal combustion was understood to be the principle source of airborne soot and fine particles. Most of the coal used in the U.S. today is burned by power plants for the production of electricity. Among power plants, the oldest coal-fired facilities produce the largest share of the particle-related air pollution. Just over half of all power plant boilers in the U.S. are fueled by coal. However, coal-burning power plants account for nearly 90 percent of the SO_2 emitted by all power plants.[22]

Because of the now obvious associations between health, fine particles, and coal-fired electric generation, health researchers have recently made preliminary estimates of the relative contribution of power plants to total deaths. Using rudimentary analysis, researchers at the Harvard School of Public Health have estimated that power plants are responsible for approximately 15,000 deaths per year (i.e., one-quarter of an assumed 60,000 fine particle related deaths per year).[23] Indeed, embedded in EPA's Regulatory Impact Analysis for the $PM_{2.5}$ fine particle health standard was the power sector's contribution to death and disease from particles in our air.[24] Similarly, in EPA's cost-benefit analysis of the Clean Air Act, health benefits associated with reductions in power plant-generated fine particle pollution provided strong justification for pollution control costs imposed by the Act.[25] A recent Harvard School of Public Health study of two coal-fired power plants in Massachusetts found that the fine particle pollution from these plants may be associated with over 100 deaths annually.[26]

Washington Must Act!

Despite steps underway to reduce power plant emissions, a major hurdle remains: to date, the vast majority of coal- and oil-fired power plants have circumvented the most protective air emissions standards required of modern power plants. When the Clean Air Act was amended in 1970 and 1977, it was assumed that many of the nation's older power plants would be retired and replaced by cleaner, new power plants and therefore should be exempt from the emission regulations governing new plants. However, for a variety of reasons, these plants have not retired. Because of this "grandfathering" loophole, coal-fired power plants are largely exempt from modern, state-of-the-art pollution control requirements. The vast majority of these plants fail to meet modern pollution standards for SO_2 and NO_x. This special treatment for "grandfathered" power plants permits these facilities to pollute at rates up to 10 times that of modern coal plants.

Polluting coal-fired power plants must be made to comply with modern emission control standards. In addition, the nation's power fleet should be held to nationwide caps on all four of the key power plant pollutants, including nitrogen oxides, sulfur dioxide, mercury and carbon dioxide. Reducing power plant NO_x and SO_2 emissions by 75 percent from 1997 emissions levels will dramatically reduce fine particle pollution so we can all breathe easier. A 75 percent reduction is both necessary to protect our health, and is readily achievable. The death, hospitalizations and lost work time caused by fine particles from power plants can be reduced comprehensively only when the Clean Air Act's 30-year loophole for old dirty power plants is finally closed.

Based on the Abt Associates analysis and the robust health evidence it is based on, reducing power plant sulfur dioxide and nitrogen oxide emissions by 75 percent will save 18,000 lives ***every year***. Moreover, the technology for reducing these emissions exists today. There is no excuse for further delay. Protecting the health of our loved ones, both the old and the young, compels swift action to cut dramatically the death and disease visited upon Americans by these dirty, antiquated plants.

Federal legislation now pending would reduce particle-forming sulfur dioxide and nitrogen oxide emissions by 75 percent from 1997 levels and significantly reduce mercury, and carbon dioxide emissions. Recently, the Environment and Public Works Committee of the U.S. Senate began hearings on the issue of comprehensive power plant cleanup. Given the uncertainty facing the industry from the combination of future environmental requirements and the advent of electric industry deregulation, even some of the largest polluting power companies have called for comprehensive legislation to clearly spell out their air pollution reduction commitments into the foreseeable future. Clearly the time is ripe to save lives by cutting fine particle pollution from the electric power industry.

NATIONAL PARK SERVICE

Lawmakers must cut through the haze and deliver Americans cleaner air.

Beyond Any Reasonable Doubt

Health Research Links Fine Particles with Death and Disease

The health effects of fine particle soot have been suspected for centuries. Early records suggest that King Edward II of England in the 14th century, ordered people who fouled the air with coal smoke to be tortured. In the steel town of Donora, Pennsylvania, in October 1948, the air became so filled with pollution that people could not see across the street. About half of the population of 14,000 in the town became sick, 10 percent severely ill, and 20 deaths were attributed to the episode. In London, four years later, a deadly fog blanketed the Thames River valley when a temperature inversion trapped air pollution near ground level from December 5th to 9th. The smoke from London's industries, residential furnaces and fireplaces filled the air. By the end of the episode, the death toll climbed to over three thousand; a five-fold increase over the normal death rate.[27]

The political response to the London event was immediate and decisive — burning of soft coal was banned in central London and smokestacks and chimney heights were raised, thus sending the pollution elsewhere. As would be repeated in the United States in the ensuing decades, "dilution" was seen as the "solution to pollution." The assumption was that as the pollution dispersed over a wider area, the lower overall pollution levels would entail no adverse health effects.[28]

In the early 1970's, U.S. researchers established a statistically significant "association" between air pollution at then-current levels and death rates in a number of U.S. cities. However, these studies could not establish a cause-and-effect relationship because they did not control for a variety of other variables that could have explained the relationship. For example, seasonal variations might be indicative of the amount of time people spend indoors or the spread of infectious diseases. The state of the science in 1980 did not establish a sufficiently robust link between air pollution and death, but it suggested that detailed investigations of this relationship would be critical to improvements in public health.[29]

Since that time, there have been extensive animal and human tests on the health effects of breathing fine particles. These tests show that fine particles can harm the respiratory tract and cause cardiac failure and therefore may be responsible for significant effects on health.[30] But the conventional wisdom on air pollution's link to early death did not change until two landmark studies clearly established the link between particles and death by tracking many individuals over long time periods in different geographic areas.

• Harvard Six-Cities Study

In a 1993 article in the New England Journal of Medicine, researchers reported on a study that tracked over 8,000 people in the United States over a period of seventeen years in six cities, each characterized by a range of fine particle levels. After controlling for other factors (smoking status, body mass, occupational risks, etc.), they found the risk of death in highly polluted areas was 26 percent greater than in areas with the lowest pollution levels. The so-called Harvard "Six Cities" study also showed for the first time that there is a "linear" or straight line statistical increase in risk directly proportional to increased fine particle concentrations. This critical finding suggested that there is no safe level of fine particles to breathe.[31]

• American Cancer Society Study

In March 1995, a second landmark study was published supporting the conclusions of the Six Cities study. The American Cancer Society (ACS) study tracked over half a million adults in 151 different metropolitan areas for more than seven years. Detailed information was collected from study participants regarding their age, sex, weight, height, demographic characteristics, smoking history, alcohol use, occupational exposures, and other factors. The study found a 17 percent increase in mortality risk in areas with higher concentrations of fine particles. The investigators also found linkages between fine particles and total mortality and with cardiopulmonary disease. The researchers concluded that exposures to current levels of air pollution are shortening the lives of Americans by several years.[32]

In his book summarizing the body of evidence on fine particle health effects, Dr. John Spengler, Director of the Environmental Science and

Engineering Program of the Harvard School of Public Health, concluded that the most obvious and direct interpretation of the data is that approximately four percent of the death rate in the U.S. can be attributed to air pollution. That figure is large (approximately 60,000 deaths per year) and exceeds a hundred-fold the sum total of all deaths caused by the other pollutants that the U.S. EPA regulates.[33]

Relying on these studies and others, in 1997 EPA issued new air quality standards for fine particles. Polluting industries immediately attacked the standards and the scientific studies underlying them as "junk science." Industry critics claimed the results were likely the product of flawed statistical methodology, due to poorly controlled exposure data, or poorly controlled factors such as heat or smoking. Industry demanded the raw data be released to its paid consultants for reanalysis. However, because confidentiality and personal privacy were guaranteed to the study participants, the researchers could not agree to the requests. Instead, the researchers agreed to a third-party reanalysis by the Health Effects Institute, a non-profit organization, jointly funded by EPA and industry to be an independent and unbiased source of information on the health effects of major pollutants.

HEI Reanalysis Confirms Landmark Studies

The Health Effects Institute (HEI) reanalysis of the Six Cities and ACS studies was performed in two parts by Dr. Daniel Krewski of the University of Ottawa and Dr. Richard Burnett of Health Canada.[34] The first phase involved an intensive audit of data quality combined with an independent effort to replicate the results of the original studies using the same data and techniques. The second phase, released during the summer of 2000, focused on extensive testing of the sensitivity of the original findings to a variety of different statistical techniques and 30 different variables that industry claimed would explain the differences in mortality between the cities such as other pollutants, climate, and socio-economic factors. However, the reanalysis found that these factors made relatively little difference in the results — including the effects of temperature and smoking — with the exception of an association found between education level and relative risk of death (lower education levels were associated with higher risk).[35]

Most importantly, through its reanalysis HEI confirmed the conclusions of both studies. For the Harvard Six Cities Study, HEI found that the relative risk between Steubenville (most polluted) and Portage (least polluted) was 28 percent —two percent higher than the 26 percent in the original study. The HEI reanalysis of the ACS data found a relative risk of 14 percent higher in the most polluted city compared to the cleanest – somewhat smaller than the 18 percent that the investigators found in the original study. In its analysis for this study, Abt Associates employed the more conservative value from the reanalysis of the ACS study as the basis for the mortality estimates in the report. Thus, the reanalysis confirmed the science behind EPA's new fine particle health standard and provided additional evidence linking fine particles at current levels to serious adverse health effects. In short, the reanalysis systematically dispelled each of the arguments leveled against the original studies.[36]

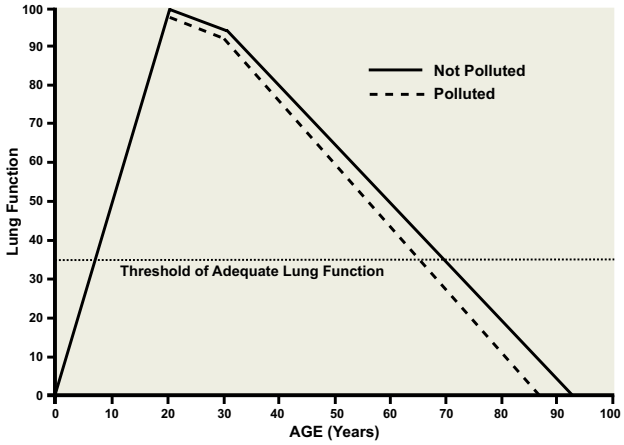
New Research Supports Association Between Particles and Death

About the same time, HEI also released the results of a completely new study of acute mortality (deaths tracked daily with air pollution levels) in the 90 largest U.S. cities. In the study—the National Morbidity and Mortality Air Pollution Study (NMMAPS) — a team of investigators from Johns Hopkins University and the Harvard School of Public Health examined increases in daily mortality and hospitalization rates caused by short-term rises in particulate matter levels in the air. The investigators developed a new standardized methodology for examining pollution effects across many different U.S. cities including state-of-the-art statistical techniques to examine the effects of multiple pollutants and the extent that lives are being shortened.[37]

The National Morbidity and Mortality Study demonstrates the life shortening power of air pollution. Industry critics have long argued that the tens of thousands of deaths associated with particulate matter in these studies are, in their words, "insignificant." They claim the victims' lives are being shortened by only a few days because they were already near death and the rise in air pollution simply provided the fatal "last straw." Scientists euphemistically labeled this notion "harvesting."

NMMAPS categorically demonstrates that the concept of harvesting is incorrect. If the industry arguments were valid, then the death rate should fall below average as air pollution levels return to normal — following the "harvest" of frail individuals. But, in fact, just the opposite is true. Instead of a harvest, researchers observed that the death rate remains higher than normal for some time, lingering

Schematic of Lung Function vs. Age Showing Loss of Life Expectancy



well beyond the time of the high air pollution episode and indicating that individuals weakened by the high air pollution levels continue to die for weeks or months following the air pollution event.[38] Moreover, recent analyses of chronic (i.e., long-term) exposure support the conclusion that life expectancy in more polluted areas is reduced by several years.[39]

Critics have also argued that other pollutants may be responsible for observed health effects and mortality attributed to particles. But, using new methods NMMAPS and the reanalysis carefully isolated the impact of particulate matter. In fact, NMMAPS found strong evidence linking daily increases in particle pollution to increases in death in the largest U.S. cities. The association between particulate matter and mortality persisted even when other pollutants were considered.[40]

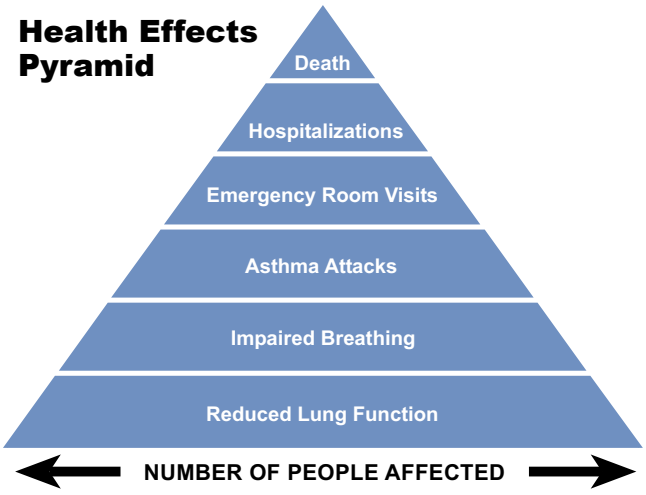
Studies Link Fine Particles to a Range of Adverse Health Effects

- Hospital Admissions

NMMAPS provides the best evidence to date for fine particles' link to a broad range of effects leading to hospitalization.[41] While previous studies established the link between fine particles and asthma-related hospital admissions, including a 1999 study which confirmed the relationship between increases in fine particle pollution and hospital admissions for asthma,[42] NMMAPS found robust associations between fine particle levels and increased hospital admissions for cardiovascular disease, pneumonia, and chronic obstructive pulmonary disease.

• Emergency Room Visits

Several other important studies also tie fine particle levels to emergency room visits. For example, fine particles were associated with emergency room visits for asthma in Seattle, Washington; Barcelona, Spain; and Steubenville, Ohio.[43] Studies have linked air pollution with both hospital admissions and emergency room visits. There is more data on hospital admissions that allows researchers to derive more complete estimates. Abt Associates based its emergency room visit estimates solely on asthma-related emergency room visits estimated in studies. Estimates of emergency room visits for other respiratory-related diagnoses must await additional studies. Thus, the estimate for asthma-related emergency room visits likely understates the total attributable to power plants.[44]



• Asthma Attacks

While these studies of hospital admissions and emergency room visits provide evidence that exposure to fine particles is directly associated with asthma attacks, researchers have also examined the relationship between air pollution and less severe asthma attacks that do not result in hospitalization. Studies in Denver, Los Angeles, and the Netherlands found that substantial increases in asthma attacks were linked with fine particle exposure.[45]

• Bronchitis

Several studies in the mid-1990's provide evidence that regular exposure to particle pollution over a number of years also gives rise to the development of chronic bronchitis.[46] These studies have been undertaken with groups of Seventh-Day Adventists, a religious order that forbids smoking, in order to control for smoking as a factor that could confound the health effects observed.[47]

New Research Links Fine Particle Pollution to Heart Attacks

Extensive new research published over the past year finds that fine particles at levels routinely found in many U.S. cities may trigger sudden deaths by changing heart rhythms in people with existing cardiac problems.[48] While further research is needed, these early studies are extremely important because cardiovascular disease is the number one killer in the United States, responsible for nearly half of all deaths. While heart rhythms in healthy persons remain largely unaffected by fine particle pollution, for those with existing heart disease fine particle exposures could have deadly consequences.[49] The threat seems particularly acute for elderly people who have existing heart arrhythmia—a life-threatening condition of rapid, skipped or premature beats—or the combination of a weak heart and lung disease such as asthma. The studies suggest that people are dying within 24 hours after elevated particulate matter exposures. About a dozen major scientific studies in the United States, recently completed or underway, are turning up evidence of heart pattern changes in animals exposed in laboratories and in elderly people tested in nursing homes.[50]

Similarly, a study of 13,000 children ages 8-12 found that higher levels of fine particle pollution were related to acute bronchitis.[51]

- Other Respiratory Symptoms

Many other studies have also found a link between fine particle pollution and a whole range of well-known upper and lower respiratory symptoms associated with air pollution including: deep, wet cough; running or stuffy nose; and burning, aching, or red eyes.[52] Associations between fine particles and more general measures of acute disease have also been found. For example, one study evaluated the impact of fine particle levels on lost work days from workers calling in sick,[53] an association that suggests an impact of air pollution on the U.S. economy, while other studies link particles and non-work restricted activity.[54]

How the Analysis was Performed

The Clean Air Task Force commissioned Abt Associates, the consulting firm relied upon by U.S. EPA to assess the health benefits of many of the agency's air regulatory programs, to quantify the power industry's share of the toll of death and disease from fine particles in the U.S. The objective of the study was to quantify the health impacts of fine particles from power plants, as well as the expected benefits (avoidable deaths, hospitalizations, etc.) of policies that would require all power plants to meet the same modern emission standards. For comparison, the study also estimated the health effects attributable to fine particle pollution from all diesel trucks, buses, locomotives, and construction equipment in the U.S. The health endpoints analyzed included death, hospitalizations, emergency room visits, asthma attacks, and a variety of lesser respiratory symptoms.

To analyze the avoidable health impacts of fine particles based on existing and hypothetical policy scenarios, the Clean Air Task Force asked Abt Associates to run three cases using methods developed for and employed by the U.S Environmental Protection Agency, extensively reviewed by EPA's Science Advisory Board, and accepted by the U.S. Office of Management and Budget in a variety of regulatory impact and assessment contexts.

In its analysis, Abt Associates assumed full implementation of the power industry's current air pollution reduction commitments, even though all of the required emission reductions have not yet occurred. The base case assumed full implementation of EPA's Summer Smog rule (i.e., the NO_X SIP Call) and implementation through 2007 of the Acid Rain program. Abt Associates analyzed the following scenarios:

1. Base case: full implementation to 2007 of the Acid Rain program (Phases 1 and 2) and EPA's Summer Smog rule (the NO_X SIP Call);
2. Base case in 2007 minus all power plant emissions — subtracting power plant emissions from the base case

Steps in the Analysis

gives us the health endpoints due solely to power plant emissions;

3. Base case in 2007 minus a 75 percent reduction in NO_X and SO_2 from 1997 levels.[55]

Abt Associates (health endpoint assessment and damage valuation) led the study team with support from ICF Consulting (power system economics and air quality modeling), and the E. H. Pechan (emissions and air quality modeling).

- ## Power System Economics
  (ICF Consulting)

The first module of the model involves power system economics and asks the question: how will the power system respond to the imposition of the costs of cleanup? Possible compliance responses by the plants include reducing emissions through emission control equipment, obtaining emission reduction credits from other plants that "overcontrolled" their emissions relative to their required emission reduction levels, reduced utilization of the plant, or retirement and replacement with other sources of electricity. The analysis assumed that the power sector will meet the proposed pollution reduction goals in the most cost-effective manner available and provides critical information on the spatial distribution of power plant emissions before and after cleanup. ICF Consulting, EPA's power system modeling consultant, ran its Integrated Planning Model (IPM) to determine the spatial distribution of emissions under the various scenarios. In running the model, ICF Consulting used inputs and assumptions consistent with EPA's Clean Air Power Initiative (CAPI) modeling analysis and other recent regulatory impact work.

- ## Air Quality Modeling
  (E. H. Pechan and ICF Consulting)

The outputs from the IPM provide the power plant emission inputs to the air quality modeling work performed by ICF and by Pechan. First, they assembled the emissions inventory for all non-power plant sources of NO_X, SO_2 and direct particulate emissions. Using the power plant emissions inputs from ICF Consulting, Pechan and ICF ran EPA's PM air quality models: Source-Receptor matrix (used to model the NO_X SIP Call and other regulatory actions) and Regional Emission Modeling System for Acidic Deposition (REMSAD) (approved by EPA's science advisory board and used in the Clean Air Act cost-benefit study). Both air quality models were used to estimate the baseline fine particle contributions attributable to the power plants and the reductions in pollutant concentrations due to the targeted reductions. The inputs and assumptions used by Pechan and ICF are consistent with recent projects performed by Pechan and by ICF for EPA, such as the regional NO_X rule (SIP Call), automobile emissions standards (Tier 2), and other similar analyses. The health effects estimates reported here are based on the REMSAD modeling outputs.

- ## Health Impacts Analysis
  (Abt Associates)

The air pollution concentration outputs from ICF and Pechan's air quality analysis provided the inputs for Abt Associates' health effects modeling. Then utilizing health studies described above which link changes in ambient fine particle concentrations to changes in risk of mortality and morbidity, pollution concentration-response functions were derived that quantify the relationship between the fore-casted changes in exposure and the expected changes in specific health effects. Abt Associates then used the modeled changes in pollutant concentrations (from the base case to the emission reduction scenarios) to estimate the power plant-attributable health impacts from each. The difference between the base case and the emission reduction scenario yielded estimates of the health benefits (or avoided adverse impacts).

Once the avoidable health impacts were determined, the monetary value of each of the various health endpoints was estimated through economic valuation techniques previously used in EPA analyses. Given the attributable and avoided health impacts calculated, Abt Associates tallied the health damages — from lost work and cost of emergency room care, to the statistical value of human lives lost from power plant emissions — and estimated the benefits of the health impacts avoided under the cleanup scenario. The methodology employed by Abt Associates was consistent with current and previous damage valuation work for EPA, and has been extensively reviewed by the EPA Science Advisory Board.

The full Abt Associates report is available at the Clear the Air website
www.cleartheair.org

The Policy Landscape

These compelling findings come at a time of growing public concern over power plant pollution. From Acid Rain, to summer smog, to the dirty haze that hangs over our national parks and wildlands, to the mercury contamination of the fish we eat, to the threat posed by global warming, power plants' contribution to a host of environmental ills is better understood than ever. No other single industry comes close to matching the variety and magnitude of public health and environmental impacts as those from electric power plants.

Fortunately, U.S. EPA and several states have begun to focus on mitigating the myriad problems of power plant pollution:

- This fall, states in the eastern U.S. are required by federal regulation to submit plans to significantly reduce by 2003-2004 their emissions that contribute to the problem of summer smog. The cornerstone of this requirement involves reductions in summertime emissions of smog-forming pollutants from power plants.
- EPA and the State of New York have launched enforcement actions against several power companies for violations of the federal law governing their emissions where it appears that for years these companies have made life-extending investments in old, dirty coal-fired plants without upgrading their pollution controls.
- By the end of 2000, the Administration has promised to propose regulations governing power plant emissions as they affect our national parks.
- Pending a Supreme Court decision to affirm the new fine particle health standard in the face of industry's challenge, states that violate the standard will be required to develop fine particle emissions reduction plans.
- New York, Connecticut, Texas and Massachusetts currently have regulations under development that could significantly reduce emissions from their power plants.

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Most importantly, federal legislation now pending would reduce particle-forming sulfur dioxide and nitrogen oxide emissions by 75 percent from 1997 levels and significantly reduce mercury and carbon dioxide emissions. Recently, the Environment and Public Works Committee of the U.S. Senate began hearings on the issue of comprehensive power plant cleanup. Given the uncertainty facing the industry from the combination of future environmental requirements and the advent of electric industry deregulation, even some of the largest polluting power companies have called for comprehensive legislation to clearly spell out their air pollution reduction commitments into the foreseeable future.

Recommendations

Old Dirty Power Plants Must Reduce Fine Particle-Causing Emissions

Polluting coal-fired power plants must be made to comply with modern emissions control standards. In addition, the nation's power fleet should be held to nationwide caps on all four of the key power plant pollutants, including nitrogen oxides, sulfur dioxide, mercury and carbon dioxide. Reducing power plant NO_X and SO_2 emissions by 75 percent from 1997 emissions levels will dramatically reduce fine particle pollution so we can all breathe easier. A 75 percent reduction is necessary to protect our health and is readily achievable. The deaths, hospitalizations and lost work time caused by fine particles from power plants can be reduced comprehensively only when the Clean Air Act's 30-year loophole for old, dirty power plants is finally closed. Requirements such as these can ensure that U.S. energy policy better accounts for the public health and environmental costs associated with electricity production and will propel us toward a more sustainable energy future that relies increasingly on renewable energy resources and conservation.

Now that policymakers know that simply cleaning up power plants to modern emission standards could save over 18,000 lives per year, there is no excuse for further delay. Protection of public health compels swift action to dramatically cut the death and disease visited upon Americans each year by these dirty, antiquated plants.

Simply cleaning up power plants to modern emission standards could save over 18,000 lives per year.

Endnotes

1 Wilson, Richard, and Spengler, John eds. *Particles in Our Air: Concentrations and Health Effects* (1999) p. 212.

2 Schwartz, J., "Air Pollution Deadlier than Previously Thought," Harvard School of Public Health, press release, March 2, 2000.

3 U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, 1996 Staff Papers on Smog and Soot Pollution: "Review of the National Ambient Air Quality Standards for Ozone and Particulate Matter." (1996).

4 "The Clean Energy Act," S. 1369, Cong. Rec. S.8585 (daily ed. July 14, 1999); "The Clean Smokestacks Act," H.R. 2900,106th Cong., 2d Sess., Cong. Rec.H.8467 (daily ed. Sept. 21, 1999).

5 These figures assume full implementation of the power industry's current air pollution reduction commitments (i.e., Acid Rain Phase 2 and the NOx SIP Call) through the year 2007, and thus understate the impacts of power plant pollution at today's emission levels.

6 Mothers Against Drunk Driving online at http://www.madd.org/pub_pol/rts2000/rts-overview.shtml

7 Source: U.S. Centers for Disease Control and Prevention, National Center for Health Statistics, "Deaths: Final Data for 1998," Volume 48, Number 11, July 24, 2000, Table 19, p. 72, available on-line at http://www.cdc.gov/nchs/about/major/dvs/mortdata.htm

8 From 1982 through 1996, an estimated 85,000 lives were saved by safety belts, averaging more than 6,000 lives saved per year over that time period. U.S. Department of Transportation, Bureau of Transportation Statistics, 1997. Transportation Statistics Annual Report. Washington, D.C.

9 National Hospital Discharge Summary 1998, U.S. Centers for Disease Control and Prevention, Advance Data #316 (June 30, 2000) available online at http://www.cdc.gov/nchs

10 Woodruff, T.J., Grillo, J. and Schoendorf, K.C.. *The Relationship Between Selected Causes of Postneonatal Infant Mortality and Particulate Air Pollution in the United States*. Environmental Health Perspectives, 105(6), June 1997. Available online at http://ehpnet1.niehs.nih.gov/docs/1997/105-6/woodruffabs.html

11 Ibid.

12 U.S. Centers for Disease Control and Prevention, *Asthma: A Public Health Response*. Available online at www.cdc.gov/nceh/programs/asthma; American Lung Association, Asthma Fact Sheet. Available online at www.lungusa.org/asthma/merck_fact.html

13 U.S. EPA, OAR, "Air Quality Criteria for Particulate Matter". Available online at http://www.epa.gov/nceawww1/pm_vol1.htm; U.S. EPA (EPA 1995b), "EPA Review of the National Ambient Air Quality Standards for Particulate Matter" External Review draft (November 1995).

14 U.S. EPA, "National Air Quality and Emission Trends Report, 1998" (March 2000), EPA 454/R00-003 Table A-8, p. 125. Available online at http://www.epa.gov/oar

15 U.S. EPA, Acid Rain Program, "National SO_2 Emissions Trend for all Title IV Affected Units," contained in "Emissions Scorecard 1998." Available online at http://www.epa.gov/acidrain/score98/es1998.htm

16 U.S. EPA, "National Air Quality and Emission Trends Report, 1998" (March 2000), Table A-6, p. 124. Available online at http://www.epa.gov/oar

17 Ibid., p.125.

18 Ibid.

19 U.S. EPA, "National Air Quality and Emission Trends Report, 1998" (March 2000), Table A-4, p. 122. Available online at http://www.epa.gov/oar

20 Ibid., p.122-124.

21 Wilson and Spengler, *Particles in Our Air* at 46.

22 U.S. EPA, Acid Rain Program, "National Summary Percent Contribution by Unit Fuel Type." Available online at http://www.epa.gov/acidrain/emissions/us_sum.htm

23 Wilson and Spengler, *Particles in Our Air* at 212.

24 National Ambient Air Quality Standards for Particulate Matter, Final Rule 62 Federal Register 138 (July 18, 1997) available online at http://www.epa.gov/ttn/oarpg/naaqsfin/

25 U.S. EPA, OAQPS, "The Benefits and Costs of the Clean Air Act 1990 to 2010" EPA-410-R-99-001 (November 1999) available online at http://www.epa.gov/airprogm/oar/sect812/index.html

26 J. Levy and J. Spengler, *Estimated Health Impacts of Criteria Pollutant Air Emissions from the Salem Harbor and Brayton Point Power Plants*, Harvard School of Public Health (May 2000) available online at http://www.hsph.harvard.edu

27 Wilson and Spengler, *Particles in Our Air* at 2.

28 Ibid. at 6-9

29 Ibid. at 6-9

30 Amdur, M. "Animal Toxicology" in Wilson and Spengler, *Particles in Our Air* at 85.

31 Dockery, D.W., Pope, C.A., Xu, S., Spengler, J.D., et al. *An Association Between Air Pollution and Mortality in Six U.S. Cities*, 329 New England J. Med. 1753-59 (1993). Available online at http://www.nejm.org/content/1993/0329/0024/1753.asp

32 Pope, C.A., Thun, M.J., Namboordiri, M.M., Dockery, D.W., et al. *Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults*. 151 Am. J. Respir. Crit. Care Med. 669-74 (1995). Available online at http://ajrccm.atsjournals.org/search.shtml

33 Wilson and Spengler, *Particles in Our Air* at 211.

34 Krewski, D., Burnett, R.T., Goldberg, M.S., Hoover, K., Siemiatycki, J., Jerrett, M., Abrahamowicz, A. and White, W.H., *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Matter and Mortality*; Health Effects Institute, Cambridge MA, (Research Report, PrePrint version, July 2000).

35 Ibid.

36 Ibid.

37 Samet, J.M., Dominici, F., Zeger, S.L., Schwartz, J., Dockery, D.W., *National Morbidity, Mortality and Air Pollution Study; Part I: Methods and Methodologic Issues*; Health Effects Institute Research Report No. 94, Cambridge MA (May 2000).

38 Ibid. at section 4, p. 51; Schwartz, J., *Harvesting and Long-Term Exposure Effects in the Relation between Air Pollution and Mortality*, 151 American Journal of Epidemiology No. 5, p. 440-448 (2000).

39 Pope, C. A., *Epidemiology of Fine Particulate Air Pollution and Human Health: Biologic Mechanisms and Who's at Risk?* 108 Env. Health Persp. (Supp. 4) 713-723 (August 2000); Brunkreef, B., *Air Pollution and Life Expectancy: Is there a Relation?* 54 Occup. & Env. Medicine 781-784 (1997).

40 Samet, J.M., Zeger, S.L., Dominici, F., Curriero, F., Coursac, I., Dockery, D.W., Schwartz, J., Zanobetti, A.; *The National Morbidity, Mortality and Air Pollution Study Part II: Morbidity, Mortality, and Air Pollution in the United States*. Health Effects Institute Research Report No. 94, Part II Cambridge, MA (June 2000) http://www.healtheffects.org.

41 Ibid.

42 Sheppard, L., Levy, D., Norris, G., Larson, T.V., and Koenig, J.Q., *Effects of ambient air pollution on nonelderly asthma hospital admissions in Seattle, Washington, 1987-1994*. 10 Epidemiology 23-30 (1999).

43 Schwartz, J., Slater, D., Larson, T.V., Pierson, W.E., and Koenig, J.Q., *Particulate air pollution and hospital emergency room visits in Seattle*. 147(4) Am Rev. Respir. Dis. 826-831 (1993); Sunyer, J., Anto, J.M, Murillo, C., and Saez, M., *Effects of urban pollution on emergency room admissions for chronic obstructive pulmonary disease*, 134 Amer, J. Epidemiol. 227-289 (1991); Sunyer, J., Saez, M., Murillo, C., Castellsague, J., Martinez, F., and Anto, J.M., *Air Pollution and emergency room admission for chronic obstructive pulmonary disease,* 137 Amer. J. Epidemiol. 701-705 (1993); Samet, J.M., Speizer, F., Bishop, E., Spengler, J.D., and Ferris, B.G., Jr. *The relationship between air pollution and emergency room visits in an industrial community* 31 J. Air Poll. Control Assoc. 31:236-240 (1981).

44 The Center for Vital Statistics of the Centers for Disease Control reports that nationally there are three emergency room visits for every hospital admission. *Ambulatory Care, Visits to Physicians Offices, Hospital Outpatient and Emergency Room Visits in the U.S.,* Centers for Disease Control, Vital Health and Statistics Series 13, No 143 (1997). Several studies confirm this ratio as it applies to respiratory-related illness. See Richards, W., Azen, S.P., Weiss, J., Stocking. S., and Church, J. *Los Angeles air pollution and asthma in children*. 47(5 Pt 1) Ann. Allergy. 348-354, 350 (1981); Lipfert, F.W. *A Critical Review of Studies of the Association between Demands for Hospital Services and Air Pollution*. 101 (S2) Env. Health Persp. 229-268, 230 (1993); and Smith, D.H., Malone, D.C., Lawson, K.A., Okamoto, L.J., Battista, C., and Saunders, W.B. *A national estimate of the economic costs of asthma*. 156 (3 Pt 1) Am. J. Respir. Crit. Care Med. 787-793, 789 (1997). This suggests that total attributable emergency room visits are likely on the order of three times total attributable hospital admissions.

45 Ostro, B.D., Lipsett, M.J., Wiener, M.B., and Selner, J.C., *Asthmatic response to airborne acid aerosols* 81 Amer. J. Public Health 694-702 (1991); Whittemore, A.S. and Korn, E.L. *Asthma and air pollution in the Los Angeles Area,* 70 Amer. J. Public Health 687-696 (1980); Roemer, W., Hoek, G., and Brunekreef, B., *Effect of ambient winter air pollution on respiratory health of children with chronic respiratory symptoms*, 147 Amer. Rev. Resp. Disease 118-124 (1993).

46 Schwartz, J., *Particulate Air Pollution and Chronic Respiratory Disease*. 62 Environ Res. 7-13 (1993); Abbey, D.E., Ostro, B.E., Petersen, F., and Burchette, R.C. *Chronic Respiratory Symptoms Associated with Estimate Long-Term Ambient Concentrations of Fine Particulates Less Than 2.5 Microns in Aerodynamic Diameter (PM 2.5) and Other Air Pollutants*. 5(2) J. Expo Anal. Environ Epidemiol. 137-159 (1995); Abbey, D.E., Petersen, F., Mills, P.K. and Beeson, W.L. *Long-Term Ambient Concentrations of Total Suspended Particulates, Ozone, and Sulfur Dioxide and Respiratory Symptoms in a Nonsmoking Population.* 48(1) Archives of Environmental Health 33-46 (1993).

47 Abbey et al. (1995; 1993); See also, McDonnell, W.F., Abbey, D.E., Nishino, N. and Lebowitz, M.D. *Long-Term ambient ozone concentration and the incidence of asthma in nonsmoking adults: the Ahsmog Study* 80 Environ. Res. 110-121 (1999).

48 Gold, D. et al., *Ambient Pollution and Heart Rate Variability*, Circulation, v. 101, 1267-1273, American Heart Association (March 21, 2000).

49 Peters, A. et al, *Increases in Heart Rate Variability During an Air Pollution Episode,* 150 American Journal of Epidemiology, p.1094-1098 (1999).

50 Los Angeles Times (June 5, 2000); See e.g., Peters, A. et al. *Air Pollution and Incidence of Cardiac Arrhythmia,* 11 Epidemiology, no 1, p. 11-17 (2000); Schwartz, J., *Air Pollution and Hospital Admissions for Heart Disease in Eight U.S. Counties*, 10 Epidemiology 17-22 (1999).

51 Dockery, D.W., Cunningham, J., Damokosh, A.I., Neas, L.M., Spengler, J.D., Koutrakis, P., Ware, J.H., Raizenne, M. and Speizer, F.E. *Health Effects of Acid Aerosols on North American Children - Respiratory Symptoms,* 104(5) Environ. Health Persp. 500-505 (1996); Dockery, D.W., Pope, C.A., Xu, X.P., Spengler, J.D. and Ferris, Jr., B.G. *Effects of Inhalable Particles on Respiratory Health of Children.* 139 Am. Rev. Respir. Dis. 587-594 (1989).

52 Pope, C.A., Dockery, D.W., Spengler, J.D. and Raizenne, M.E. *Respiratory Health and PM10 Pollution - a Daily Time Series Analysis,* 144(3) Am Rev. Resp. Dis. 668-674 (1991); Pope, C.A. and Dockery, D.W. *Acute Health Effects of PM10 Pollution On Symptomatic and Asymptomatic Children* 145(5) Am. Rev. Resp. Dis. 1123-1128 (1992); Hoek, F. and Brunekreef, B., *Acute effects of a winter air pollution episode on pulmonary function and respiratory symptoms of children*, 48 Arch. Environ. Health 328-335 (1993); Hoek, G. and Brunekreef, B., *Effects of low level winter air pollution concentrations on respiratory health of Dutch children,* 48 Environ. Research 328-335 (1994); Schwartz, J., Dockery, D.W., Neas, L.M., Wypij, D., Ware, J.H., Spengler, J.D., Koutrakis, P., Speizer, F.E., and Ferris, B.G., *Acute effects of summer air pollution on respiratory symptom reporting in children*, 150 Amer. J. Respir. Crit. Care Med. 1240-1242 (1994); Ostro, B.D., Lipsett, M.J., Mann, J.K., Krupnick, A., and Harrington, W., *Air pollution and respiratory morbidity among adults in Southern California*, 137 Amer. J. Epidemiol. 691-700 (1993); Roemer, W., Hoek, G., and Brunekreef, B., *Effect of ambient winter air pollution on respiratory health of children with chronic respiratory symptoms*, 147 Amer. Rev. Resp. Disease 118-124; Neas, L.M., Dockery, D.W., Spengler, J.D., Speizer, F.E., and Tollerud, D.J., *The association of ambient air pollution with twice daily peak expiratory flow measurements in children*, 145(4) Amer. Rev. Resp. Disease 429 (1992).

53 Ostro, B.D. *Air Pollution and morbidity revisited: A specification test*, 14 J. Environ. Econ. Manage. 87-98 (1987).

54 Ostro, B.D. and Rothschild, S., *Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants*. 50(2) Environ. Res. 238-247; Krupnick, A.J., Harrington, W. and Ostro, B., *Ambient Air Pollution and Acute Health Effects - Evidence from Daily Data*. 18(1) Journal of Environ. Econ. and Management. 1-18 (1990).

55 In addition, for comparison purposes, Abt Associates analyzed the base case minus all on- and off-road mobile diesel particulate emissions.

Appendix

Health Effects from Power Plant Pollution by State

State	Mortality	Total Hospital-izations	Asthma ER Visits	Chronic Bronchitis	Asthma Attacks	Lost Work Days	Restricted Activity Days	Deaths per 100,000 adults
Alabama	1,110	701	246	627	20,600	173,000	886,000	42.8
Arizona	52	41	14	37	1,230	9,880	51,200	1.8
Arkansas	479	304	93	250	8,050	66,400	341,000	30.7
California	259	200	89	215	7,410	62,100	322,000	1.4
Colorado	64	48	22	56	1,800	16,000	82,800	2.5
Connecticut	299	213	71	197	6,040	52,800	271,000	15.4
Delaware	126	88	33	84	2,760	22,900	117,000	26.8
District of Columbia	118	64	23	60	1,900	17,500	89,900	41.3
Florida	1,740	1,350	342	1,010	30,800	245,000	1,260,000	17.1
Georgia	1,630	1,050	472	1,120	38,200	333,000	1,700,000	35.5
Idaho	8	6	2	6	192	1,530	7,950	1.0
Illinois	1,700	1,110	391	1,020	33,100	283,000	1,450,000	24.8
Indiana	1,030	679	244	623	20,500	173,000	886,000	30.0
Iowa	299	211	63	173	5,490	45,500	235,000	18.1
Kansas	274	185	62	163	5,300	44,600	230,000	16.7
Kentucky	997	635	229	578	19,000	161,000	819,000	44.1
Louisiana	481	291	118	284	9,800	81,900	422,000	20.1
Maine	55	36	12	34	1,060	9,090	46,900	7.3
Maryland	927	608	256	648	20,900	185,000	947,000	28.8
Massachusetts	441	313	104	283	8,880	78,000	401,000	12.3
Michigan	871	579	221	566	18,500	159,000	817,000	16.3
Minnesota	249	182	69	178	5,820	49,900	258,000	9.0
Mississippi	489	299	108	264	9,110	74,200	380,000	32.2
Missouri	896	569	184	494	15,800	133,000	684,000	28.5
Montana	6	4	1	4	116	954	4,950	1.0
Nebraska	122	84	28	73	2,390	19,900	103,000	12.5
Nevada	16	12	5	13	425	3,360	17,400	1.4
New Hampshire	67	46	18	48	1,540	13,500	69,800	9.3
New Jersey	1,100	758	259	708	21,900	189,000	967,000	21.9
New Mexico	23	17	7	17	599	4,880	25,300	2.1
New York	1,870	1,260	437	1,180	37,000	321,000	1,650,000	18.1
North Carolina	1,800	1,200	447	1,140	37,100	322,000	1,640,000	38.6
North Dakota	18	13	4	11	360	2,950	15,300	4.7
Ohio	1,920	1,250	442	1,150	37,100	313,000	1,600,000	29.7
Oklahoma	412	256	85	228	7,340	61,800	318,000	21.0
Oregon	43	31	11	29	912	7,740	40,100	2.0
Pennsylvania	2,250	1,510	445	1,240	38,400	318,000	1,620,000	32.0
Rhode Island	88	63	19	53	1,660	14,300	73,400	14.8
South Carolina	791	509	201	493	16,600	141,000	721,000	36.0
South Dakota	33	24	7	19	622	5,010	25,900	7.4
Tennessee	1,440	910	323	839	27,100	232,000	1,190,000	42.3
Texas	1,310	885	382	929	31,700	274,000	1,410,000	11.5
Utah	17	16	8	16	656	4,450	22,900	1.5
Vermont	32	22	8	22	692	6,030	31,100	8.6
Virginia	1,240	823	341	856	27,900	246,000	1,260,000	30.3
Washington	44	34	13	34	1,100	9,250	48,000	1.2
West Virginia	459	286	87	238	7,390	61,000	310,000	43.3
Wisconsin	448	317	109	288	9,340	79,300	409,000	14.6
Wyoming	7	5	2	5	183	1,490	7,710	2.3

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State	Mortality	Hospital-izations	Asthma ER Visits	Chronic Bronchitis	Total Asthma Attacks	Lost Work Days	Restricted Activity Days
Alabama	738	459	160	416	13,500	116,000	594,000
Arizona	11	8	3	8	251	2,150	11,200
Arkansas	277	174	53	144	4,610	38,400	198,000
California	49	36	15	38	1,280	11,200	58,400
Colorado	23	17	8	20	640	5,840	30,400
Connecticut	197	137	46	128	3,890	34,900	179,000
Delaware	80	53	20	51	1,640	14,600	74,900
District of Columbia	80	42	15	40	1,250	11,800	60,800
Florida	1,050	760	192	582	17,300	148,000	763,000
Georgia	1,090	688	309	747	25,200	223,000	1,140,000
Idaho	5	4	1	4	117	965	5,010
Illinois	981	635	222	589	19,000	164,000	848,000
Indiana	585	379	136	354	11,500	99,300	512,000
Iowa	183	128	38	106	3,330	27,800	144,000
Kansas	162	108	36	96	3,120	26,500	137,000
Kentucky	578	360	129	335	10,900	93,500	480,000
Louisiana	306	183	74	180	6,190	52,300	270,000
Maine	37	24	8	23	707	6,160	31,800
Maryland	619	397	166	428	13,700	124,000	638,000
Massachusetts	278	193	64	175	5,450	49,100	253,000
Michigan	523	343	131	338	11,000	95,600	493,000
Minnesota	153	111	42	108	3,530	30,600	159,000
Mississippi	318	192	69	171	5,880	48,400	249,000
Missouri	519	324	104	284	9,020	77,200	399,000
Montana	3	2	1	2	66	548	2,840
Nebraska	69	47	16	42	1,350	11,400	59,100
Nevada	5	3	1	3	109	982	5,110
New Hampshire	45	30	12	32	1,020	9,090	47,000
New Jersey	718	481	163	453	13,900	123,000	634,000
New Mexico	7	5	2	5	175	1,470	7,640
New York	1,200	792	273	744	23,200	206,000	1,060,000
North Carolina	1,190	771	287	744	24,000	213,000	1,100,000
North Dakota	10	7	2	6	207	1,730	8,950
Ohio	1,200	768	269	712	22,800	196,000	1,010,000
Oklahoma	250	154	51	138	4,420	37,500	194,000
Oregon	31	21	7	20	631	5,430	28,200
Pennsylvania	1,460	947	278	791	24,200	207,000	1,060,000
Rhode Island	57	40	12	34	1,060	9,380	48,300
South Carolina	515	324	127	318	10,600	91,900	472,000
South Dakota	19	14	4	11	354	2,880	14,900
Tennessee	857	533	188	500	15,900	139,000	715,000
Texas	805	534	229	565	19,100	168,000	868,000
Utah	7	6	3	6	246	1,900	9,820
Vermont	21	14	5	14	450	3,970	20,500
Virginia	828	542	223	571	18,400	166,000	855,000
Washington	31	23	9	23	744	6,390	33,200
West Virginia	296	181	55	153	4,700	39,700	203,000
Wisconsin	268	188	65	172	5,550	47,600	246,000
Wyoming	3	2	1	2	66	563	2,920

Health Effects from Power Plant Pollution Top 50 Metro Areas

State	Mortality	Total Hospital-izations	Asthma ER Visits	Chronic Bronchitis	Asthma Attacks	Lost Work Days	Restricted Activity Days
New York, NY	2,290	1,580	546	1,490	46,200	402,000	2,060,000
Washington, DC	1,140	764	354	881	28,600	257,000	1,320,000
Philadelphia, PA	997	654	225	593	19,000	158,000	808,000
Chicago, IL	995	648	256	651	21,400	186,000	957,000
Atlanta, GA	647	432	237	550	18,700	169,000	866,000
Pittsburgh, PA	585	395	105	309	9,210	75,500	385,000
Detroit, MI	527	343	134	343	11,200	96,400	496,000
St. Louis, MO	494	309	109	285	9,200	77,300	397,000
Tampa, FL	494	409	86	271	8,070	57,200	293,000
Boston, MA	454	320	113	302	9,540	84,000	432,000
Akron, OH	442	293	96	261	8,170	69,300	355,000
Cincinnati, OH	377	248	95	236	7,870	66,400	339,000
Dallas, TX	369	247	129	304	10,500	94,100	486,000
Greensboro, NC	309	210	77	201	6,380	56,000	286,000
Charlotte, NC	298	201	83	206	6,780	59,200	302,000
Nashville, TN	260	167	71	175	5,800	51,200	262,000
Birmingham, AL	257	164	57	148	4,760	40,200	205,000
Louisville, KY	256	162	59	152	4,870	41,200	210,000
Indianapolis, IN	250	161	64	161	5,300	45,400	233,000
Greenville, SC	226	148	54	139	4,520	39,100	200,000
Norfolk, VA	217	144	69	158	5,580	48,600	249,000
Richmond, VA	203	128	50	128	4,100	36,000	184,000
Columbus, OH	201	132	59	142	4,790	42,700	219,000
Houston, TX	201	132	76	178	6,140	54,400	281,000
Kansas City, MO	194	126	49	127	4,100	35,500	183,000
Knoxville, TN	190	130	44	118	3,730	32,200	164,000
Memphis, TN	185	107	46	110	3,780	32,500	167,000
Los Angeles, CA	184	143	65	156	5,440	45,400	236,000
Dayton, OH	181	115	42	109	3,520	30,300	155,000
Raleigh, NC	174	125	58	139	4,700	43,300	222,000
Milwaukee, WI	163	110	40	104	3,370	28,700	148,000
Chattanooga, TN	154	96	34	89	2,820	24,200	123,000
Johnson City, TN	154	98	30	84	2,580	22,200	113,000
New Orleans, LA	152	89	36	89	2,990	25,200	130,000
Orlando, FL	152	116	41	108	3,490	29,900	154,000
Buffalo, NY	149	98	29	82	2,530	21,400	110,000
Minneapolis, MN	135	99	45	113	3,750	33,200	172,000
Jacksonville, FL	131	84	35	87	2,910	24,500	126,000
Scranton, PA	122	79	19	57	1,680	13,700	69,700
Youngstown, OH	120	77	22	63	1,920	15,600	79,500
Harrisburg, PA	116	79	26	70	2,190	18,800	96,000
Augusta, GA	112	66	31	71	2,470	21,100	108,000
Hartford, CT	110	77	27	72	2,240	19,700	101,000
Tulsa, OK	108	68	27	69	2,230	19,300	99,300
Sarasota, FL	105	98	13	52	1,390	9,340	47,800
Lexington, KY	95	63	28	65	2,250	20,300	104,000
Allentown, PA	94	67	20	56	1,700	14,200	72,800
San Antonio, TX	93	67	29	69	2,410	20,500	106,000
Mobile, AL	92	61	22	56	1,860	15,300	78,600
Rochester, NY	90	62	23	59	1,900	16,300	84,000

...and Avoided with 75% Power Plant Pollution Reduction

State	Mortality	Total Hospital-izations	Asthma ER Visits	Chronic Bronchitis	Asthma Attacks	Lost Work Days	Restricted Activity Days
New York, NY	1,470	991	341	945	29,000	259,000	1,330,000
Washington, DC	762	501	231	585	18,800	173,000	890,000
Philadelphia, PA	647	406	138	373	11,700	102,000	527,000
Chicago, IL	572	368	145	373	12,200	107,000	553,000
Atlanta, GA	431	283	154	366	12,300	113,000	581,000
Pittsburgh, PA	371	241	63	192	5,620	48,000	246,000
Detroit, MI	322	207	80	209	6,740	59,100	305,000
Tampa, FL	291	211	43	143	4,040	33,400	172,000
Boston, MA	287	198	69	188	5,880	53,200	274,000
Akron, OH	283	185	60	166	5,160	44,500	229,000
St. Louis, MO	280	170	59	159	5,060	43,900	227,000
Dallas, TX	228	151	78	187	6,390	58,200	302,000
Cincinnati, OH	223	144	55	139	4,590	39,500	203,000
Greensboro, NC	207	137	50	134	4,180	37,700	193,000
Charlotte, NC	191	125	51	131	4,240	37,900	194,000
Birmingham, AL	174	109	38	100	3,170	27,300	140,000
Norfolk, VA	150	97	46	107	3,750	33,600	173,000
Nashville, TN	149	95	40	101	3,300	29,600	152,000
Greenville, SC	145	93	34	89	2,860	25,200	129,000
Indianapolis, IN	145	91	36	92	3,000	26,500	137,000
Louisville, KY	145	89	32	85	2,690	23,400	120,000
Richmond, VA	138	85	33	86	2,730	24,600	126,000
Columbus, OH	128	83	37	90	3,020	27,400	141,000
Houston, TX	127	82	47	111	3,820	34,300	178,000
Raleigh, NC	118	82	38	93	3,120	29,400	151,000
Kansas City, MO	116	75	29	76	2,430	21,300	110,000
Knoxville, TN	114	76	26	70	2,200	19,400	99,800
Dayton, OH	109	68	25	65	2,090	18,300	94,200
Memphis, TN	109	62	27	65	2,210	19,200	99,100
Chattanooga, TN	100	61	21	57	1,800	15,700	80,400
Buffalo, NY	99	64	19	54	1,660	14,300	73,400
Milwaukee, WI	97	64	23	62	1,980	17,100	88,500
New Orleans, LA	97	56	22	56	1,890	16,100	83,400
Johnson City, TN	93	58	18	51	1,530	13,400	69,000
Orlando, FL	88	65	23	61	1,930	17,400	89,800
Minneapolis, MN	83	60	27	69	2,270	20,400	106,000
Scranton, PA	82	52	12	38	1,110	9,260	47,500
Youngstown, OH	78	49	14	40	1,220	10,200	52,200
Harrisburg, PA	76	51	16	46	1,410	12,400	63,500
Augusta, GA	74	43	20	47	1,620	14,000	72,100
Jacksonville, FL	74	46	19	47	1,560	13,900	71,800
Hartford, CT	72	49	17	46	1,430	12,900	66,400
Tulsa, OK	66	41	16	42	1,360	11,900	61,400
Sarasota, FL	64	54	7	30	758	5,720	29,500
Allentown, PA	63	43	13	37	1,100	9,490	48,700
Mobile, AL	61	40	14	37	1,220	10,200	52,600
Rochester, NY	59	40	14	38	1,220	10,700	55,200
Columbia, SC	56	36	17	41	1,400	12,800	66,000
Lexington, KY	56	36	16	38	1,300	11,900	61,300
Huntington, WV	55	32	10	28	871	7,450	38,100

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