Compilation of Recent Abstracts (2002-2007) - Health Effects Associated with Thermal Electricity Generation

Prepared for:
Clean Air Strategic Alliance
Electricity Project Team

Prepared by:
Adrienne LeBlanc, MSc

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List of Abbreviations

AHW	Alberta Health and Wellness
ATSDR	Agency for Toxic Substances and Disease Registry
CASA	Clean Air Strategic Alliance
EPA	Environmental protection Agency
HCB	Hexachlorobenzene
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCTO	Public Citizen's Texas Office
PM	Particulate Matter
TSPs	Total Suspended Particulates
VOCs	Volatile Organic Carbons
WVDHHR	West Virginia Department of Health and Human Resources

1. Introduction

1.1. Objective of Report

To aid in the five-year review of the *Emissions Management Framework for the Alberta Electricity Sector* (CASA Electricity Project Team 2003a), a search of recent white and grey literature (published between 2002 and 2007) was undertaken. Documents pertaining to health effects associated with thermal electricity generation emissions were collected. This report offers the findings of the literature search and provides a compilation of suitable abstracts.

This report merely presents a compilation of recent abstracts. No attempt was made to critique the articles or assess the quality of the science in the studies. Judgement of the quality of the science is beyond the scope of this report.

1.2. Summary of Literature Search Findings

In total, 37 white literature sources assessing health effects from thermal electrical generation emissions were found through searches of literature databases or through regulatory agency websites. In terms of grey-literature, 19 articles related to health effects of thermal electrical generation emissions were found. A detailed description of the literature search methods can be found in Section 1.3.

1.3. Literature Search Methodology

1.3.1. White Literature Articles

A literature search was performed to capture current information regarding emissions and health effects associated with electrical generation. Literature searches using the databases *ISI Web of Science*, *Ovid EMBASE*, and *Toxnet* were conducted to identify original, published, peer-reviewed material. As this report is intended as a review of new information following a report completed in 2003 (CASA Electricity Project Team 2003a), the search was limited to studies published between January 2002 and December 2007. Only articles published in English were accepted. The search terms and the number of articles identified by each database search are shown in Table 1.

Altogether, 28 relevant original articles (after removal of duplicates) were obtained from the database searches, one of which was included as grey literature material. Articles were considered relevant if the study was an original document pertaining to health effects associated with thermal electricity generation. Review papers were not considered relevant. Also, studies assessing occupational exposures to electrical generation emissions were excluded, as these exposures do not typically represent community exposures. Studies evaluating pollutant control technologies were also excluded unless health effects data was specifically stated. Articles assessing environmental effects, such as studies of the effects of power plant emissions on fish,

soil, and microorganisms, were considered irrelevant as environmental effects will be evaluated in a separate report.

Table 1. Results from three literature searches

	Search Terms	Number of Articles Identified:		
		ISI Web of Science	Ovid EMBASE	Toxnet
1. Include studies containing atleast one of the following TERMS:	Coal; Fossil fuel; Gas; Lignite;	>100,000	48,976	
2. From (1), include studies containing atleast one of the following TERMS:	Electric-; Power generation; Power plant; Power station	11,670	1772	706
3. From (2), include studies containing atleast one of the following TERMS:	Epidemiol-; Health; Morbidity; Mortality; Risk;	415	268	207
Number of relevant original articles:		**19**	**17**	**26**

1.3.2. Grey Literature Reports

Reports and other scientific articles were obtained through searches of the individual websites of government agencies and environmental groups. Suitable agencies/groups to explore were identified in two ways: (1) Commissioning agencies identified in white literature articles, and (2) Known governmental and regulatory agencies in North America, such as Health Canada or the Agency for Toxic Substances and Disease Registry (ATSDR). Original documents pertaining to health effects from thermal electrical generation were obtained by searching on each website for publications or documents containing any of the following terms: Coal, Gas, Electrical Generation, Emissions, Fossil Fuel, Power, or Oil. Relevant articles were identified in the same manner as discussed in Section 1.3.1. Articles found through the agency website search that had already been retrieved via the search discussed in Section 1.3.1 were excluded. The agencies and groups contacted, as well as the number of relevant documents found, are shown in Table 3.

Altogether, 17 grey literature reports were obtained using this search method. Published journal articles that were found via the individual agency website searches were included with the peer-reviewed journal articles (white literature abstracts) rather than with the grey literature abstracts.

1.3.3. Additional Searching

To ensure all available articles were found, a supplementary search was completed. This was accomplished in two ways. Firstly, a 'related articles' search was completed in the *Pubmed* database. Selected articles retrieved in the original literature search (Section 1.3.1) were entered into *Pubmed*; the lists of related articles for each original article were searched for any new relevant documents. 7 new articles were retrieved using this search

method. Secondly, a search of the citations of recent articles was conducted. Citations from a number of grey and white literature articles were searched, and 2 new relevant articles were found.

Additionally, one grey literature article (Levy 2006) was forwarded by the CASA group.

1.3.4. Literature Search Uncertainties

Although attempts were made to capture all relevant electricity generation health effects abstracts, there is the potential that pertinent studies were not found by the literature search methods. The literature search results may be limited by the capabilities of the database search engines, the particular search terms used, and organizations that were missed in the agency website searches.

For the grey literature search, some governmental agencies or environmental groups may not have made relevant documents publicly available online through their websites. This may have also caused important documents to be missed.

For the above-mentioned reasons, it must be noted that data gaps may exist because of the potential to miss relevant articles.

Table 2. Government agencies and environmental groups searched for electrical generation health effects documents

Agency or Group	Country	Website	# of Relevant Reports Found
Air Impacts	Global	www.airimpacts.org	**0**
Alberta Environment	Canada	www.environment.gov.ab.ca	**0**
Alberta Health and Wellness	Canada	www.health.gov.ab.ca	**1**
ATSDR	USA	www.atsdr.cdc.gov	**1**
Brookhaven National Laboratory (BNL)	USA	www.bnl.gov	**2**
Clean Air Task Force (CATF)	USA	www.catf.us	**2**
Commission for Environmental Cooperation	Canada/USA/Mexico	www.cec.org	**0**
Electric Power Research Institute (EPRI)	USA	www.epri.com	**0**
Environment Canada	Canada	www.ec.gc.ca	**0**
Environmental Integrity Project	USA	www.environmentalintegrity.org	**2**
Environmental Protection Agency (EPA)	USA	www.epa.gov	**1**
European Commmission - Environment	European Union	www.ec.europa.eu/environment	**0**
Geological Survey of Canada	Canada	www.gsc.nrcan.gc.ca	**0**
Government of British Columbia	Canada	www.gov.bc.ca	**0**
Government of Ontario	Canada	www.gov.on.ca	**2**
Government of Saskatchewan	Canada	www.gov.sk.ca	**0**
Greenpeace Canada	Canada	www.greenpeace.ca	**0**
Greenpeace USA	USA	www.greenpeace.org	**0**
Health Canada	Canada	www.hc-sc.gc.ca	**0**
Health Effects Institute (HEI)	USA	www.healtheffects.org	**0**
International Joint Commission (IJC)	Canada/USA	www.ijc.org	**0**
National Energy Technology Laboratory	USA	www.netl.doe.gov	**3**
NY State Energy Research Development Auth	USA	www.nyserda.org	**0**
Ontario Clean Air Alliance (OCAA)	Canada	www.cleanairalliance.org	**0**
Ontario Power Generation (OPG)	Canada	www.opg.com	**0**
Sustainable Energy Econ. Develop. (SEED)	USA	www.seedcoalition.org	**2**
Toronto Public Health	Canada	www.toronto.ca/health	**1**
United Nations Economic Development	Global	www.unep.org	**0**
World Resources Institute (WRI)	USA	www.wri.org	**0**

2. Health Effects Associated with Electrical Generation Emissions

2.1 Five Priority Substances

The five priority substances identified in the CASA Emissions Management Framework are mercury (Hg), sulphur dioxide (SO_2), nitrogen oxides (NO_X), primary particulate matter (PM), and greenhouse gases (primarily carbon dioxide (CO_2)) (CASA Electricity Project Team 2003a). Priority substances were identified based on a comprehensive list of environmental, health, and emissions criteria (CASA Electricity Project Team 2003b). The majority of health effects studies found were related to emissions of the five priority substances.

A recent Alberta Health and Wellness study completed a community exposure and health effects assessment in the Wabamun-Genesee area (Alberta Health and Wellness 2006). Exposure levels and health effects of Hg, SO_2, NO_2, and $PM_{2.5}$ were evaluated. Other important documents to note include three studies completed in Ontario assessing the health impacts of PM and other criteria pollutants (DSS Management Consultants Inc. and RWDI Air Inc. 2005; Pengelly and Sommerfreund 2004; Yap, et al. 2005).

There were several epidemiology studies looking at the health effects of PM from the combustion of fossil fuels (Aekplakorn, et al. 2003; Carbonell, et al. 2007; Diniz da Costa and Pagan 2006; Gilmour, et al. 2007; Greene and Morris 2006; Levy, Greco and Spengler 2002; Lewis, et al. 2005; Li, et al. 2004; O'Neill, et al. 2005; Peacock, et al. 2003; Venners, et al. 2003), as well as five modeling studies (Chen, et al. 2007; Hermann, Divita and Lanier 2004; Levy and Spengler 2002; Lopez, et al. 2005; US EPA 2003). Also, the toxicology of PM, dust, and ash from combustion of fossil fuels was assessed in *in vitro* studies (Antonini, et al. 2004; Veranth, Veranth and Yost 2004; Wang, et al. 2003; Wang, et al. 2005) and in two animal toxicology studies (Gilmour, et al. 2007; Smith, et al. 2006). In the grey literature, PM was also the focus of numerous studies (Abt Associates 2002a; Abt Associates 2004; Chang, et al. 2002; Clean Air Task Force 2002; Levy 2006; Rohr 2006a; Rohr 2006b; Rohr 2007).

The health effects of mercury emissions from coal-fired power plants have been addressed in both white literature studies (Trasande, Landrigan and Schechter 2005; Trasande, et al. 2006a; Trasande, et al. 2006b) and the grey literature studies (Alberta Health and Wellness 2006; Rice and Hammitt 2005; Sullivan, et al. 2003; Sullivan, et al. 2005). Studies of NO_X and SO_2 also showed up a number of times in both the white (Aekplakorn, et al. 2003; Carbonell, et al. 2007; Chen, et al. 2007; Diniz da Costa and Pagan 2006; Dockery, et al. 2005; Dubnov, et al. 2007; Levy and Spengler 2002; Levy, Greco and Spengler 2002; Lopez, et al. 2005; Mohorovic 2003; Mohorovic 2004; Peacock, et al. 2003; Pisani, et al. 2006; Portnov, Dubnov and Barchana 2007; Venners, et al. 2003) and grey literature (Abt Associates 2002b; Chang, et al. 2002; Public Citizen's Texas Office 2006).

2.2 List 2 Substances

List 2 substances are chemicals that may potentially be released during electricity generation that do not meet the criteria set out for priority substances, yet warrant further assessment based on a potential to cause adverse effects (CASA Electricity Project Team 2003a). There are fifteen List 2 substances identified in the CASA Emissions Management Framework:

Hydrogen fluoride (HF)	Hydrogen chloride (HCl)
Arsenic (As)	Cadmium (Cd)
Chromium (Cr)	Cobalt (Co)
Lead (Pb)	Manganese (Mn)
Selenium (Se)	Dioxins/furans
Hexachlorobenzene (HCB)	Benzene
Beryllium (Be)	Polycyclic aromatic hydrocarbons (PAHs)
Thallium (Tl)	

Of the List 2 substances, PAHs (Alberta Health and Wellness 2006; Tang, et al. 2006), benzene (Alberta Health and Wellness 2006), and metals (mainly As and Pb) (Alberta Health and Wellness 2006; Ranft, et al. 2003; Wilhelm, et al. 2005) were assessed in health effects studies.

2.3 Emerging Chemicals

The major chemicals focused on in the health effects studies were included in either the five priority substances or the List 2 substances. No 'emerging chemicals' were immediately apparent.

2.4 List of Abstracts

Tables 3 and 4 provide a summary of the abstracts for white and grey literature, respectively, compiled for health effects related to thermal electricity generation emissions. For easier navigation, the abstracts listed in these tables are organized by geographic location. Following these tables is the collection of abstracts related to health effects.

Table 3. Summary of thermal electricity generation health effects abstracts (white literature)

Year	Author	Title	Fuel Type	Chemicals of Interest	Page #
Asia - China					
2003	Venners	Particulate matter, sulfur dioxide, and daily mortality in Chongqing, China	Coal	$PM_{2.5}$, SO_2	19
2003	Wang	Presence of estrogenic activity from emission of fossil fuel combustion as detected by a recombinant yeast bioassay	Coal	Dust	20
2004	Li	Quantifying the human health benefits of curbing air pollution in Shanghai	Coal	PM_{10}	23
2005	Wang	Inhibition of progesterone receptor activity in recombinant yeast by soot from fossil fuel combustion emissions and air particulate materials	Coal	Dust	34
2006	Tang	PAH–DNA adducts in cord blood and fetal and child development in a Chinese cohort	Coal	PAHs	41
2007	Chen	Low-carbon energy policy and ambient air pollution in Shanghai, China: A health-based economic assessment	Coal, Gas	PM_{10}, SO_2	45
Asia - India					
2005	Ghose	Assessment of the status of urban air pollution and its impact on human health in the city of Kolkata	Unknown	CO, NO_X, Pb, PM, SO_2	28
Asia - Israel					
2005	Peled	Fine particles and meteorological conditions are associated with lung function in children with asthma living near two power plants	Coal, Oil	$PM_{2.5}$, PM_{10}	32
2007	Dubnov	Estimating the effect of air pollution from a coal-fired power station on the development of children's pulmonary function	Coal	NO_X, SO_2	46
2007	Portnov	On ecological fallacy, assessment errors stemming from misguided variable selection, and the effect of aggregation on the outcome of epidemiological study	Coal	NO_X, SO_2	48
Asia - Thailand					
2003	Aekplakorn	Acute effect of sulphur dioxide from a power plant on pulmonary function of children, Thailand	Lignite coal	PM_{10}, SO_2	15
2006	Pisani	GSTM1 and CYP1A1 polymorphisms, tobacco, air pollution,and lung cancer: A study in rural Thailand	Coal	NO_2, SO_2, TSPs	38
Australia					
2006	Diniz Da Costa	Sustainability metrics for coal power generation in Australia	Coal	NO_X, PM_{10}, SO_X	36
Europe - Croatia					
2003	Mohorovic	The level of maternal methemoglobin during pregnancy in an air-polluted environment	Coal	SO_2	16
2004	Mohorovic	First two months of pregnancy—critical time for preterm delivery and low birthweight caused by adverse effects of coal combustion toxics	Coal	SO_2	24
Europe - England					
2003	Peacock	Acute effects of winter air pollution on respiratory function in schoolchildren in southern England	Unknown	NO_X, O_3, PM_{10}, SO_2, SO_4^{2-}	17

Year	Author	Title	Fuel Type	Chemicals of Interest	Page #
Europe - Italy					
2004	Parodi	Lung cancer mortality in a distric of La Spezia (Italy) exposed to air pollution from industrial plants	Coal	Heavy metals	25
Europe - Slovakia					
2002	Pesch	Environmental arsenic exposure from a coal-burning power plant as a potential risk factor for nonmelanoma skin carcinoma: Results from a case-control study in the District of Prievidza, Slovakia	Coal	As	14
2003	Ranft	Association between arsenic exposure from a coal-burning power plant and urinary arsenic concentrations in Prievidza District, Slovakia	Coal	As	18
2005	Wilhelm	Comparison of arsenic levels in fingernails with urinary As species as biomarkers of arsenic exposure in residents living close to a coal-burning power plant in Prievidza District, Slovakia	Coal	As	35
Europe - Turkey					
2002	Karavus	Respiratory complaints and spirometric parameters of the villagers living around the Seyitomer coal-fired thermal power plant in Kutahya, Turkey	Lignite coal	Not measured	11
North America - Cuba					
2007	Carbonell	Assessment of the impacts on health due to the emissions of Cuban power plants that use fossil fuel oils with high content of sulfur. Estimation of external costs	Crude oil,Fuel oil	NH_3, NO_X, PM_{10}, SO_X	44
North America - Mexico					
2005	Lopez	Health impacts from power plant emissions in Mexico	Fuel oil	NO_X, $PM_{2.5}$, SO_2	30
North America - United States					
2002	Levy	Modeling the benefits of power plant emission controls in Massachusetts	Coal	NO_X, $PM_{2.5}$, SO_2	12
2002	Levy	The importance of population susceptibility for air pollution risk assessment: A case study of power plants near Washington, DC	Unknown	NO_X, $PM_{2.5}$, SO_2	13
2004	Antonini	Metal composition and solubility determine lung toxicity induced by residual oil fly ash collected from different sites within a power plant	Oil, Gas	Residual oil fly ash	21
2004	Hermann	Predicting premature mortality from new power plant development in Virginia	Unknown	$PM_{2.5}$	22
2004	Veranth	Induction of IL-6 in lung cells by $PM_{2.5}$ particles from desert soils and coal fly ash	Bituminous coal	$PM_{2.5}$	26
2005	Dockery	Association of air pollution with increased incidence of ventricular tachyarrhythmias recorded by implanted cardioverter defibrillators	unknown	CO,NO_2, O_3, $PM_{2.5}$, SO_2, SO_4^{2-}	27
2005	Lewis	Air pollution–associated changes in lung function among asthmatic children in Detroit	Coal	O_3, $PM_{2.5}$, PM_{10}	29
2005	O'Neill	Diabetes enhances vulnerability to particulate air pollution–associated impairment in vascular reactivity and endothelial function	Coal	$PM_{2.5}$, black carbon, SO_4^{2-}	31
2005	Trasande	Public health and economic consequences of methyl mercury toxicity to the developing brain	Coal	Hg, Methylmercury	33

Year	Author	Title	Fuel Type	Chemicals of Interest	Page #
North America - United States cont'd					
2006	Greene	Assessment of public health risks associated with atmospheric exposure to $PM_{2.5}$ in Washington, DC, USA	Unknown	$PM_{2.5}$, Heavy metals	37
2006	Smith	Acute pulmonary and systemic effects of inhaled coal fly ash particles in rats: Comparison to ambient environmental particles	Bituminous coal	PM_1, $PM_{2.5}$	40
2006	Trasande	Applying cost analyses to drive policy that protects children	Coal	Hg, Methylmercury	42
2006	Trasande	Mental retardation and prenatal methylmercury toxicity	Coal	Hg, Methylmercury	43
2007	Gilmour	Comparative toxicity of size-fractionated airborne particulate matter obtained from different cities in the United States	Coal	PM_{10}, $PM_{2.5}$, $PM_{0.1}$	47

Table 4. Summary of thermal electricity generation health effects abstracts (grey literature)

Year	Author	Title	Fuel Type	Chemicals of Interest	Page #
Asia - China					
2002	Chang	Assessment of the health benefits of controlling air pollution in Shanghai, China	Coal	NO_X, $PM_{2.5}$, PM_{10}, SO_2, TSPs	51
North America - Canada					
2004	Pengelly	Air Pollution-Related Burden of Illness in Toronto: 2004 Update	Coal	CO, NO_2, O_3, $PM_{2.5}$, SO_2	56
2005	DSS Management	Cost Benefit Analysis: Replacing Ontario's Coal-Fired Electricity Generation	Coal	O_3, $PM_{2.5}$	58
2005	Yap	Transboundary Air Pollution in Ontario	Coal	O_3, $PM_{2.5}$	60
2006	AHW	Wabamun and Area Community Exposure and Health Effects Assessment Program	Coal	As, Hg, NO_2, O_3, SO_2, PAHs, $PM_{2.5}$, VOCs, Organic acids	64
North America - United States					
2002	Abt Associates	Particulate-Related Health Impacts of Eight Electric Utility Systems	Coal, Gas, Oil	PM	49
2002	Abt Associates	Particulate-Related Health Impacts of Emissions in 2001 from 41 Major US Power Plants	Unknown	NO_X, PM, SO_2	50
2002	Clean Air Task Force	Health Impacts of Air Pollution from Washington DC Area Power Plants	Coal, Oil	$PM_{2.5}$	52
2003	EPA	Technical Addendum: Methodologies for the Benefit Analysis of the Clear Skies Act of 2003	Unknown	Hg, NO_X, O_3, $PM_{2.5}$, SO_2	53
2003	Sullivan	Assessing the Mercury Health Risks Associated With Coal-Fired Power Plants: Impacts of Local Depositions	Coal	Hg	54
2004	Abt Associates	Power Plant Emissions: Particulate Matter-Related Health Damages and the Benefits of Alternative Emission Reduction Scenarios	Coal	$PM_{2.5}$	55
2005	Rice	Economic Valuation of Human Health Benefits of Controlling Mercury Emissions from U.S. Coal-Fired Power Plants	Coal	Hg	61
2005	Sullivan	Mercury Emissions from Coal Fired Power Plants - Local Impacts on Human Health Risk	Coal	Hg	62
2005	WVDHHR	Health Consultation, Chauncey PCB Site, Review of EPA Sample Data for Nov 2003 Through Mar 2004, Chauncey, Logan County, West Virginia	Coal	As, Pb, Pesticides	63
2006	Levy	Analysis of Particulate Matter Impacts for Six Power Plants in Maryland	Unknown	$PM_{2.5}$	65
2006	PCTO	Premature Mortality from Proposed New Coal-fired Power Plants in Texas	Coal	NO_X, SO_2	67
2006	Rohr	Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA): Application to Power Plant-Derived $PM_{2.5}$. Topical Report: Plant 0 (Upper Midwest)	Coal	$PM_{2.5}$	68
2006	Rohr	Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA): Application to Power Plant-Derived $PM_{2.5}$. Topical Report: Plant 1 (Southeast)	Coal	$PM_{2.5}$	69
2007	Rohr	Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA): Application to Power Plant-Derived $PM_{2.5}$	Coal	$PM_{2.5}$	71

2.4.1. White Literature Articles

Title: Respiratory complaints and spirometric parameters of the villagers living around the Seyitomer coal-fired thermal power plant in Kutahya, Turkey	
Year: 2002	**Author:** Karavus, M. *et. al.*
Commissioning Agency: Research Committee of the Rectorate of the Univ. of Marmara	

Study Details:

Study Location: Turkey	**Study Design:** Ecological study
Fossil Fuel Type: Lignite coal	
Chemicals of Interest: Pollutant levels not measured	

Abstract:

The aim of the study was to investigate the respiratory effects of the stack emissions of the Seyitömer coal-fired thermal power plant in the Kutahya Province of Turkey. The three villages that are located within 5 km around the power plant were investigated as our "Villages around Power Plant." Two villages which were similar to the Villages around Power Plant as far as climate, culture, and lifestyle were concerned and which were located more than 30 km away from the thermal power plant were investigated as our "Control Villages." The study design was based on the comparison of the respiratory complaints and the spirometric parameters of the individuals living in the two groups of villages. The study was carried out on individuals of 15 years of age and above living in these villages (277 of 302 individuals living in the Villages around Power Plant and 225 of 264 living in the Control Villages). Among the ones living in the Villages around Power Plant, 46.2% had complaints of chest tightness and 29.2% repeated coughing attacks present for more than one year, whereas these percentages were 28.0 and 20.4% in the Control Villages, the differences being statistically significant (P = 0.001 and P =0.024, respectively). The complaint of productive coughing present for more than one year was not found to differ statistically significantly between the two groups of villages (P = 0.0885). The means of the spirometric parameters of FEV1 and FEF25+75% were found to be statistically significantly lower in the individuals of the Villages around Power Plant compared to the individuals of the Control Villages (P = 0.0001 and P = 0.0001, respectively). When the spirometric parameters of nonsmokers were compared between the two groups of villages, FEV1, FVC, and FEF25+75% were found to be statistically significantly lower in the Villages around Power Plant compared to the Control Villages (P = 0.0001, P = 0.0001, and P = 0.0001, respectively). No statistically significant differences of the spirometric measurements of current smokers were observed between the two groups of villages (P > 0.05). The spirometric parameters revealed statistically significant adverse health effects of the Power Plant, this was particularly apparent for the nonsmokers. More specific tests to confirm the diagnosis of acute and chronic lung diseases can be suggested to be carried out in the area in further studies. Also follow-up studies can be recommended in the area to detect any new adverse health effects of the Power Plant.
(Karavus, et al. 2002)

Title: Modeling the benefits of power plant emission controls in Massachusetts	
Year: 2002	**Author:** Levy, J.I. *et. al.*
Commissioning Agency: Clean Air Task Force / Pew Charitable Trusts / Kresge Center for Environmental Health	

Study Details:

Study Location: Massachusetts, USA	**Study Design:** Modelling study
Fossil Fuel Type: Coal	
Chemicals of Interest: NO_X, $PM_{2.5}$, SO_2	

Abstract:

Older fossil-fueled power plants provide a significant portion of emissions of criteria air pollutants in the United States, in part because these facilities are not required to meet the same emission standards as new sources under the Clean Air Act. Pending regulations for older power plants need information about any potential public health benefits of emission reductions, which can be estimated by combining emissions information, dispersion modeling, and epidemiologic evidence. In this article, we develop an analytical modeling framework that can evaluate health benefits of emission controls, and we apply our model to two power plants in Massachusetts. Using the CALPUFF atmospheric dispersion model, we estimate that use of Best Available Control Technology (BACT) for NO_X and SO_2 would lead to maximum annual average secondary particulate matter (PM) concentration reductions of 0.2 $\mu g/m^3$. When we combine concentration reductions with current health evidence, our central estimate is that the secondary PM reductions from these two power plants would avert 70 deaths per year in a population of 33 million individuals. Although benefit estimates could differ substantially with different interpretations of the health literature, parametric perturbations within CALPUFF and other simple model changes have relatively small impacts from an aggregate risk perspective. While further analysis would be required to reduce uncertainties and expand on our analytical model, our framework can help decision-makers evaluate the magnitude and distribution of benefits under different control scenarios.
(Levy and Spengler 2002)

Title: The importance of population susceptibility for air pollution risk assessment: A case study of power plants near Washington, DC	
Year: 2002	**Author:** Levy, J.I. *et. al.*
Commissioning Agency: Clean Air Task Force / Pew Charitable Trusts / Kresge Center for Environmental Health	

Study Details:

Study Location: District of Columbia, USA	**Study Design:** Case study
Fossil Fuel Type: Specific fossil fuel not stated	
Chemicals of Interest: NO_X, $PM_{2.5}$, SO_2	

Abstract:

In evaluating risks from air pollution, health impact assessments often focus on the magnitude of the impacts without explicitly considering the distribution of impacts across subpopulations. In this study, we constructed a model to estimate the magnitude and distribution of health benefits associated with emission controls at five older power plants in the Washington, DC, area. We used the CALPUFF atmospheric dispersion model to determine the primary and secondary fine particulate matter (< 2.5 μm in aerodynamic diameter) concentration reductions associated with the hypothetical application of "Best Available Control Technology" to the selected power plants. We combined these concentration reductions with concentration–response functions for mortality and selected morbidity outcomes, using a conventional approach as well as considering susceptible subpopulations. Incorporating susceptibility had a minimal effect on total benefits, with central estimates of approximately 240 fewer premature deaths, 60 fewer cardiovascular hospital admissions (CHA), and 160 fewer pediatric asthma emergency room visits (ERV) per year. However, because individuals with lower education appear to have both higher background mortality rates and higher relative risks for air-pollution–related mortality, stratifying by educational attainment implies that 51% of the mortality benefits accrue among the 25% of the population with less than high school education. Similarly, diabetics and African Americans bear disproportionate shares of the CHA and ERV benefits, respectively. Although our ability to characterize subpopulations is constrained by the available information, our analysis demonstrates that incorporation of susceptibility information significantly affects demographic and geographic patterns of health benefits and enhances our understanding of individuals likely to benefit from emission controls.
(Levy, Greco and Spengler 2002)

Title: Environmental arsenic exposure from a coal-burning power plant as a potential risk factor for nonmelanoma skin carcinoma: Results from a case-control study in the District of Prievidza, Slovakia	
Year: 2002	**Author:** Pesch, B. *et. al.*
Commissioning Agency: European Union	

Study Details:

Study Location: Slovakia	**Study Design:** Case-control study
Fossil Fuel Type: Coal	
Chemicals of Interest: As	

Abstract:

To investigate the risk of arsenic exposure from a coal-burning power plant in Slovakia on nonmelanoma skin cancer (NMSC) development, a 1996–1999 population-based case-control study was conducted with 264 cases and 286 controls. Exposure assessment was based on residential history and annual emissions (Asres1, Asres2) and on nutritional habits and arsenic content in food (Asnut1, Asnut2). Asres1 was assessed as a function of the distance of places of residence to the plant. Asres2 additionally considered workplace locations. Asnut1 was used to calculate arsenic uptake by weighting food frequencies with arsenic concentrations and annual consumption of food items. Asnut2 additionally considered consumption of local products. Age- and gender-adjusted risk estimates for NMSC in the highest exposure category (90th vs. 30th percentile) were 1.90 (95% confidence interval (CI): 1.39, 2.60) for Asres1, 1.90 (95% CI: 1.38, 2.62) for Asres2, 1.19 (95% CI: 0.64, 2.12) for Asnut1, and 1.83 (95% CI: 0.98, 3.43) for Asnut2. No interaction was found between arsenic exposure and dietary and residential data. Other plant emissions could have confounded the distance-based exposure variables. Consumption of contaminated vegetables and fruits could be confounded by the protective effects of such a diet. Nevertheless, the authors found an excess NMSC risk for environmental arsenic exposure.
(Pesch, et al. 2002)

Title: Acute effect of sulphur dioxide from a power plant on pulmonary function of children, Thailand	
Year: 2003	**Author:** Aekplakorn, W. *et. al.*
Commissioning Agency: Department of Health, Ministry of Public Health, Thailand	

Study Details:

Study Location: Thailand	**Study Design:** Prospective cohort study
Fossil Fuel Type: Lignite Coal	
Chemicals of Interest: PM_{10}, SO_2	

Abstract:

Background: Epidemiological studies have shown reversible declines of lung function in response to air pollution, but research on the independent effect of short-term exposure to ambient sulphur dioxide (SO_2) on pulmonary function is limited. This study evaluated the association of short-term exposure to increased ambient SO_2 and daily pulmonary function changes among children with and without asthma. Methods: The associations of daily exposure to SO_2 and particulate matter 10 μm in diameter (PM_{10}) with pulmonary function were examined in 175 asthmatic and non-asthmatic children aged 6–14 years who resided near a coal-fired power plant in Thailand. Each child performed daily pulmonary function tests during the 61-day study period. General linear mixed models were used to estimate the association of air pollution and pulmonary function controlling for time, temperature, co-pollutants, and autocorrelation.

Results: In the asthmatic children, a daily increase in SO_2 was associated with negligible declines in pulmonary function, but a small negative association was found between PM_{10} and pulmonary function. A 10-μg/m3 increment was associated with changes in the highest forced vital capacity (FVC) (–6.3 ml, 95% CI: –9.8, –2.8), forced expiratory volume at 1 second (FEV1) (–6.0 ml, 95% CI: –9.2, 2.7), peak expiratory flow rate (PEFR) (–18.9 ml.sec–1, 95% CI: –28.5, –9.3) and forced expiratory flow 25 to 75% of the FVC (FEF25–75%) (–3.7 ml.sec–1, 95% CI: –10.9, 3.5). No consistent associations between air pollution and pulmonary function were found for non-asthmatic children.

Conclusion: Declines in pulmonary function among asthmatic children were associated with increases in particulate air pollution, rather than with increases in SO_2.

(Aekplakorn, et al. 2003)

Title: The level of maternal methemoglobin during pregnancy in an air-polluted environment	
Year: 2003	**Author:** Mohorovic, L.
Commissioning Agency: PP Plomin Ltd. (Croatia Electricity Company)	

Study Details:

Study Location: Croatia	**Study Design:** Prospective cohort study
Fossil Fuel Type: Coal	
Chemicals of Interest: SO_2	

Abstract:

The objective of this prospective study was to determine if a correlation could be established between the ground-level concentrations of sulfur dioxide and methemoglobin concentrations in pregnant women when a coal-powered thermoelectric power plant was in operation ("dirty" period) and when it was closed ("clean" period). The location of the power plant, Plomin 1, in Labin, Croatia, was taken into consideration. Blood and urine samples of each pregnant woman in the study were tested three times in the clean period (n = 138) and three times in the dirty period (n = 122), with 1 month between each test. I observed a correlation between the increase in mean values of methemoglobin and the ground-level concentration of SO_2 on corresponding dates during the dirty period ($r = 0.72$, $p < 0.01$). In the clean period, the negative mean value of methemoglobin was significant ($r = -0.60$, $p \leq 0.05$), whereas in the dirty period, the positive mean value of methemoglobin was significant ($r = 0.73$, $p \leq 0.01$). The increase of maternal methemoglobin could be a useful biomarker to determine when the health of pregnant women is threatened by toxic substances in the environment.
(Mohorovic 2003)

Title: Acute effects of winter air pollution on respiratory function in schoolchildren in southern England	
Year: 2003	**Author:** Peacock, J.L. *et. al.*
Commissioning Agency: UK Department of Health	

Study Details:

Study Location: England	**Study Design:** Prospective cohort study
Fossil Fuel Type: Not stated	
Chemicals of Interest: NO_X, O_3, PM_{10}, SO_2, SO_4^{2-}	

Abstract:

Aim: To investigate the acute health effects of winter outdoor air pollution (nitrogen dioxide (NO_2), ozone (O_3), sulphur dioxide (SO_2), sulphate (SO_4^{2-}), and particles (PM_{10})) on schoolchildren in an area of southern England where levels of SO_2 had been reported to be high.

Methods: A total of 179 children, aged 7–13, from three schools (two urban and one rural location), were included. Peak respiratory flow rate (PEFR) and presence or absence of upper respiratory infections were recorded on 63 school days from 1 November 1996 to 14 February 1997. Air pollution and meteorological data were taken from monitors at each school site. The analysis regressed daily PEFR on pollutant level adjusting for confounders and serial correlation and calculated a weighted pooled estimate of effect overall for each pollutant. In addition, large decrements in PEFR were analysed as a binary outcome. Same day, lag 1, lag 2, and a five day average of pollutant levels were used.

Results: There were no clear effects of any pollutant on mean PEFR. In addition, we analysed large PEFR decrements (a binary outcome), observing consistent negative associations with NO_2, SO_4^{2-}, and PM_{10}, although few lag/pollutant combinations were significant: odds ratios (95% CI) for five day average effect: NO_2 24 h average 1.043 (1.000 to 1.089), SO_4^{2-} 1.090 (0.898 to 1.322), PM_{10} 1.037 (0.992 to 1.084). The observed effects of PM_{10} (only) were stronger in wheezy children (1.114 (1.057 to 1.174)). There were no consistent negative associations between large decrements and ozone or SO_2.

Conclusions: There is no strong evidence for acute effects of winter outdoor air pollution on mean PEFR overall in this area, but there is evidence for negative effects on large PEFR decrements.

(Peacock, et al. 2003)

Title: Association between arsenic exposure from a coal-burning power plant and urinary arsenic concentrations in Prievidza District, Slovakia	
Year: 2003	**Author:** Ranft, U. *et. al.*
Commissioning Agency: European Commission	

Study Details:

Study Location: Slovakia	**Study Design:** Case-control study
Fossil Fuel Type: Coal	
Chemicals of Interest: As	

Abstract:

To assess the arsenic exposure of a population living in the vicinity of a coal-burning power plant with high arsenic emission in the Prievidza District, Slovakia, 548 spot urine samples were speciated for inorganic As (As_{inorg}), monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), and their sum (As_{sum}). The urine samples were collected from the population of a case–control study on nonmelanoma skin cancer (NMSC). A total of 411 samples with complete As speciations and sufficient urine quality and without fish consumption were used for statistical analysis. Although current environmental As exposure and urinary As concentrations were low (median As in soil within 5 km distance to the power plant, 41 μg/g; median urinary As_{sum}, 5.8 μg/L), there was a significant but weak association between As in soil and urinary As_{sum} ($r = 0.21$, $p < 0.01$). We performed a multivariate regression analysis to calculate adjusted regression coefficients for environmental As exposure and other determinants of urinary As. Persons living in the vicinity of the plant had 27% higher As_{sum} values ($p < 0.01$), based on elevated concentrations of the methylated species. A 32% increase of MMA occurred among subjects who consumed homegrown food ($p < 0.001$). NMSC cases had significantly higher levels of As_{sum}, DMA, and As_{inorg}. The methylation index As_{inorg} /(MMA + DMA) was about 20% lower among cases ($p < 0.05$) and in men ($p < 0.05$) compared with controls and females, respectively.
(Ranft, et al. 2003)

Title: Particulate matter, sulfur dioxide, and daily mortality in Chongqing, China	
Year: 2003	**Author:** Venners, S.A. *et. al.*
Commissioning Agency: Natl. Inst. Environ. Health Sciences/V.Kann Rasmussen Fund/ World Bank Environment Project/US Department of Energy	

Study Details:

Study Location: China	**Study Design:** Cohort study
Fossil Fuel Type: Coal	
Chemicals of Interest: $PM_{2.5}$, SO_2	

Abstract:

In 1995, daily mortality in a district of Chongqing, China, was analyzed from January through December for associations with daily ambient sulfur dioxide and fine particles (airborne particles with diameters ≤ 2.5 μm; $PM_{2.5}$). The mean concentration of $PM_{2.5}$ was 147 μg/m^3 (maximum, 666 μg/m^3), and that of SO_2 was 213 μg/m^3 (maximum, 571 μg/m^3). On average, 9.6 persons died each day. We used a generalized additive model using robust Poisson regression to estimate the associations of mean daily SO_2 and $PM_{2.5}$ with daily mortality (on the same day and at lags up to 5 days) adjusted for trend, season, temperature, humidity, and day of the week. The relative risk of mortality associated with a 100 μg/m^3 increase in mean daily SO_2 was highest on the second lag day [1.04; 95% confidence interval (CI), 1.00–1.09] and the third lag day (1.04; 95% CI, 0.99–1.08). The associations between daily mortality and mean daily PM2.5 were negative and statistically insignificant on all days. The relative risk of respiratory mortality on the second day after a 100 μg/m^3 increase in mean daily SO_2 was 1.11 (95% CI, 1.02–1.22), and that for cardiovascular mortality was 1.10 (95% CI, 1.02–1.20). The relative risk of cardiovascular mortality on the third day after a 100 μg/m^3 increase in mean daily SO_2 was 1.20 (95% CI, 1.11–1.30). The relative risks of mortality due to cancer and other causes were insignificant on both days. The estimated effects of mean daily SO_2 on cardiovascular and respiratory mortality risk remained after controlling for $PM_{2.5}$.
(Venners, et al. 2003)

Title: Presence of estrogenic activity from emission of fossil fuel combustion as detected by a recombinant yeast bioassay	
Year: 2003	**Author:** Wang, J. *et. al.*
Commissioning Agency: National Natural Science Foundation of China/Germany Federal Ministry of Education and Research/Chinese Acad. of Sciences	

Study Details:

Study Location: China	**Study Design:** *in vitro* study
Fossil Fuel Type: Coal	
Chemicals of Interest: Dust	

Abstract:

Estrogenic activities of emission samples generated by fossil fuel combustion were investigated with human estrogen receptor (ER) recombinant yeast bioassay. The results showed that there were weak but clear estrogenic activities in combustion emissions of fossil fuels including coal, petroleum, and diesel. The estrogenic relative potency (RP) of fossil fuel combustion was the highest in petroleum-fired car, followed by coal-fired stove, diesel-fired agrimotor, coal-fired electric power station. On the other hand, the estrogenic relative inductive efficiency (RIE) was the highest in coal-fired stove and coal-fired electric power station, followed by petroleum-fired car and diesel-fired agrimotor. The estrogenic activities in the sub-fractions from chromatographic separation of emitted materials were also determined. The results indicated that different chemical fractions in these complex systems have different estrogenic potencies. The GC/MS analysis of the emission showed that there were many aromatic carbonyls, big molecular alcohol, PAHs and derivatives, and substituted phenolic compounds and derivatives which have been reported as environmental estrogens. The existence of estrogenic substances in fossil fuel combustion demands further investigation of their potential adverse effects on human and on the ecosystem. The magnitude of pollution due to global usage of fossil fuels makes it imperative to understand the issue of fossil fuel-derived endocrine activities and the associated health risks, particularly the aggregated risks stemmed from exposure to toxicants of multiple sources.
(Wang, et al. 2003)

Title: Metal composition and solubility determine lung toxicity induced by residual oil fly ash collected from different sites within a power plant	
Year: 2004	**Author:** Antonini, J.M. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Massachusetts, USA	**Study Design:** *in vitro* study
Fossil Fuel Type: Oil, Gas	
Chemicals of Interest: Residual oil fly ash (ROFA)	

Abstract:

Residual oil fly ash (ROFA) is a particulate pollutant comprised of soluble and insoluble metals and is produced by the combustion of fossil fuels. The objective was to examine the pulmonary responses to chemically distinct ROFA samples collected from either a precipitator or air heater within the same power plant. The collected ROFA samples were suspended in saline (total sample), incubated for 24 h at 37°C, centrifuged, separated into soluble and insoluble fractions, and the metal composition was determined. In addition, electron spin resonance (ESR) was used to detect short-lived free radical intermediates produced by the ROFA samples and the different fractions. On day 0, Male Sprague–Dawley rats were intratracheally instilled with saline (vehicle control) or the ROFA samples (1 mg/100 g body wt). At day 1, bronchoalveolar lavage was performed, and lung inflammation was assessed. On day 3, additional rats that had been treated with ROFA were intratracheally inoculated with 5×10^5 *Listeria monocytogenes*, and pulmonary bacterial clearance was measured at days 6, 8, and 10. The precipitator ROFA was found to be more soluble and acidic with a significantly greater mass of each metal compared with the air heater ROFA. A prominent hydroxyl radical signal was measured for the total and soluble precipitator ROFA after the addition of H_2O_2, whereas the air heater ROFA and its fractions did not produce a signal. Precipitator ROFA induced a greater inflammatory response than air heater ROFA illustrated by a significant elevation in lung neutrophils. In addition, pulmonary clearance of *L. monocytogenes* was greatly diminished in the rats treated with the soluble and total precipitator ROFA samples. None of the air heater ROFA samples had an effect on lung bacterial clearance. In conclusion, precipitator ROFA, particularly the soluble fraction, generated a metal-dependent hydroxyl radical as measured by ESR and was shown to cause more inflammation and result in reduced lung defense against infection compared with air heater ROFA. These results are most likely due to differences in metal composition and solubility of the ROFA samples. (Antonini, et al. 2004)

Title: Predicting premature mortality from new power plant development in Virginia	
Year: 2004	**Author:** Hermann, R.P. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Virginia, USA	**Study Design:** Modelling study
Fossil Fuel Type: Specific type of fossil fuel not stated	
Chemicals of Interest: $PM_{2.5}$	

Abstract:

The authors estimated the number of premature deaths from particulate matter less than 2.5 μm ($PM_{2.5}$) that would result from making 29 proposed fossil fuel power plants in Virginia operational. We used a U.S. Environmental Protection Agency air quality model (Climatological Regional Dispersion model) to calculate changes in ambient concentrations of $PM_{2.5}$ and Cox proportional hazard modeling to calculate the resulting premature mortality. The model predicted that if all 29 plants were operational, $PM_{2.5}$ concentrations would rise in 271 counties across 19 states 5 and increased average annual $PM_{2.5}$ concentrations would result in a rate of 17 deaths per 37,900,026 people aged 30 yr and older (0.45 deaths per million, 95% confidence interval = 0.31, 0.59) per year by the end of 2004, increasing thereafter. Over a 6 yr period, 104 cumulative excess deaths would occur due to operations of these proposed plants. The authors recommend that precautionary principles be considered when policy decisions related to energy production from fossil fuels are made.
(Hermann, Divita and Lanier 2004)

Title: Quantifying the human health benefits of curbing air pollution in Shanghai	
Year: 2004	**Author:** Li, J. *et. al.*
Commissioning Agency: United States Department of Energy	

Study Details:

Study Location: China	**Study Design: Modelling** study
Fossil Fuel Type: Coal	
Chemicals of Interest: PM_{10}	

Abstract:

Urban development in the mega-cities of Asia has caused detrimental effects on the human health of its inhabitants through air pollution. However, averting these health damages by investing in clean energy and industrial technologies and measures can be expensive. Many cities do not have the capital to make such investments or may prefer to invest that capital elsewhere. In this article, we examine the city of Shanghai, China, and perform an illustrative cost/benefit analysis of air pollution control. Between 1995 and 2020 we expect that Shanghai will continue to grow rapidly. Increased demands for energy will cause increased use of fossil fuels and increased emissions of air pollutants. In this work, we examine emissions of particles smaller than 10 mm in diameter (PM_{10}), which have been associated with inhalation health effects. We hypothesize the establishment of a new technology strategy for coal-fired power generation after 2010 and a new industrial coal-use policy. The health benefits of pollution reduction are compared with the investment costs for the new strategies. The study shows that the benefit-to-cost ratio is in the range of 1–5 for the power-sector initiative and 2–15 for the industrial-sector initiative. Thus, there appear to be considerable net benefits for these strategies, which could be very large depending on the valuation of health effects in China today and in the future. This study therefore provides economic grounds for supporting investments in air pollution control in developing cities like Shanghai.
(Li, et al. 2004)

Title: First two months of pregnancy—critical time for preterm delivery and low birthweight caused by adverse effects of coal combustion toxics	
Year: 2004	**Author:** Mohorovic, L.
Commissioning Agency: PP Plomin Ltd. (Croatia Electricity Company)	

Study Details:

Study Location: Croatia	**Study Design:** Retrospective cohort study
Fossil Fuel Type: Coal	
Chemicals of Interest: SO_2	

Abstract:

Objective: The objective of this study was to define the most critical gestation period for adverse effects of environmental toxics in terms of preterm delivery (<37 weeks) and low birthweight (<2500 g) in humans.

Study design: From January 1, 1987 to December 31, 1989, 704 women were included in a retrospective epidemiological study. All were from the district of Labin and lived in the vicinity of a coal power plant Plomin 1, Croatia. This plant is the single large source of air pollution in the area. The coal used for fuel is extremely rich with sulfur, 9–11%. Daily, weekly, and monthly consumption of coal and related SO2 emissions were calculated for each pregnant woman from the beginning to the end of pregnancy.

Results: We found that a greater and longer exposure to SO_2 emissions during the initial two months of pregnancy resulted in a significantly shorter gestation (end of the first month: -0.0914, p=0.008, end of the second month: -0.0806, p=0.016) and in lower body mass of a newborn (end of the first month: -0.0807, p=0.016, end of the second month -0.0733, p=0.026).

Conclusion: The results of this study confirm the role of inhaled environmental toxics in the early development of human embryo and in adverse pregnancy course caused by permanent oxidative stress, misbalanced production of reactive oxygen species (ROS), reactive nitrogen species (RNS), reactive sulfur species (RSS), and other unfavorable metabolic processes on early embryogenesis, resulting in growth-arrested cells.

(Mohorovic 2004)

Title: Lung cancer mortality in a distric of La Spezia (Italy) exposed to air pollution from industrial plants	
Year: 2004	**Author:** Parodi, S. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Italy	**Study Design:** Ecological study
Fossil Fuel Type: Coal	
Chemicals of Interest: Heavy metals	

Abstract:

Aims and background: In the last decades, many epidemiological studies have implicated outdoor environmental carcinogens in the onset of lung cancer. The present investigation evaluated lung cancer mortality in two areas of the Province of La Spezia (Northern Italy) exposed to environmental pollution emitted by a coal-fired power station and other industrial sources, including a waste incinerator.

Methods: In the two exposed areas, lung cancer mortality risk for the 1988-1996 calendar period was evaluated using the whole Province population as referent. The corresponding relative risks (RR) were estimated after controlling for age structure, urban/rural gradient and deprivation factors (occupation, education, home ownership, housing conditions and family structure) by a Poisson regression modeling. The geographic pattern of risk for the whole province was evaluated via the Besag,York and Mollié (BYM) bayesian model.

Results: Persons living in urban areas showed the highest rates in both sexes. No statistically significant risk excess was found in the two exposed areas among males, after excluding rural and semi-rural zones from the analyses (RR = 1.03 and RR = 0.77). In contrast, a risk excess was observed for females in both exposed areas, which remained elevated and statistically significant ($P < 0.05$) after restriction to urban/semi-urban municipalities and after controlling for deprivation factors (RR = 1.54 and RR = 2.14, respectively). Bayesian mapping confirmed the rural/urban gradient and the risk excess observed in females near the industrial sites.

Conclusions: The risk observed among females is consistent with pollution measurements and with other epidemiologic findings, whereas a strong confounding from occupational exposures and smoking habit could account for the lack of an excess risk in males. However, the ecologic nature of this investigation prevented drawing a causal inference. The pollution-related risk observed in the female gender is an important clue that deserves further epidemiologic attention.

(Parodi, et al. 2004)

Title: Induction of IL-6 in lung cells by $PM_{2.5}$ particles from desert soils and coal fly ash	
Year: 2004	**Author:** Veranth, J.M. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Western United States	**Study Design:** *in vitro* study
Fossil Fuel Type: Bituminous coal	
Chemicals of Interest: $PM_{2.5}$	

Abstract:

Fine particle air pollution is a complex mixture containing materials from geological, combustion, and atmospheric sources. The mechanisms linking various particle types to specific health effects remain elusive, but many studies have associated ambient particles with pro-inflammatory cytokine signaling pathways. In this study, $PM_{2.5}$ particles were aerodynamically separated from three western United States desert soils and from a sample of fly ash collected at a power plant burning bituminous coal. Cultured human lung epithelial cells (type BEAS-2B) were treated with doses from 10-160 $\mu g/cm^2$ of the particles. Viable cell count and the interleukin- 6 (IL-6) concentration in the media were determined 24 h after treatment. The IL-6 response correlated with negative charge on the particles (zeta potential) but did not correlate with particle surface area or with transition metal content. Capsazepine, an antagonist of the TRPV-1 receptor, decreased the IL-6 response. One desert dust induced an exceptionally high IL-6 response compared to treatment with the other soils, kaolin clay, or soluble metal salts. The LAL chromagenic assay showed that this dust contained the highest level of endotoxin (20-50 EU/mg particles which equals <10 EU/mL as applied to the cells). The measured endotoxin concentration in the dust was considerably lower that the amount of soluble lipopolysaccaride required to elicit a comparable IL-6 response (> 2000 EU/mL). This suggests that either the particles interfere with the LAL endotoxin assay or that other soil dust properties are responsible for the cytokine response.
(Veranth, Veranth and Yost 2004)

Title: Association of air pollution with increased incidence of ventricular tachyarrhythmias recorded by implanted cardioverter defibrillators	
Year: 2005	**Author:** Dockery, D.W. *et. al.*
Commissioning Agency: Health Effects Inst./Natl. Inst. Environ. Health Sciences	

Study Details:

Study Location: Massachusetts, USA	**Study Design:** Cohort study
Fossil Fuel Type: Not stated	
Chemicals of Interest: CO, NO_2, O_3, $PM_{2.5}$, SO_2, SO_4^{2-}, Black carbon	

Abstract:

Epidemiologic studies have demonstrated a consistent link between sudden cardiac deaths and particulate air pollution. We used implanted cardioverter defibrillator (ICD) records of ventricular tachyarrhythmias to assess the role of air pollution as a trigger of these potentially life-threatening events. The study cohort consisted of 203 cardiac patients with ICD devices in the Boston metropolitan area who were followed for an average of 3.1 years between 1995 and 2002. Fine particle mass and gaseous air pollution plus temperature and relative humidity were measured on almost all days, and black carbon, sulfate, and particle number on a subset of days. Date, time, and intracardiac electrograms of ICD-detected arrhythmias were downloaded at the patients' regular follow-up visits (about every 3 months). Ventricular tachyarrhythmias were identified by electrophysiologist review. Risk of ventricular arrhythmias associated with air pollution was estimated with logistic regression, adjusting for season, temperature, relative humidity, day of the week, patient, and a recent prior arrhythmia. We found increased risks of ventricular arrhythmias associated with 2-day mean exposure for all air pollutants considered, although these associations were not statistically significant. We found statistically significant associations between air pollution and ventricular arrhythmias for episodes within 3 days of a previous arrhythmia. The associations of ventricular tachyarrhythmias with fine particle mass, carbon monoxide, nitrogen dioxide, and black carbon suggest a link with motor vehicle pollutants. The associations with sulfate suggest a link with stationary fossil fuel combustion sources.
(Dockery, et al. 2005)

Title: Assessment of the status of urban air pollution and its impact on human health in the city of Kolkata	
Year: 2005	**Author:** Ghose, M.K. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: India	**Study Design:** Ecological study
Fossil Fuel Type: Not stated	
Chemicals of Interest: CO, NO_X, Pb, PM, SO_2	

Abstract:

Air pollution has significant effects on exacerbation of asthma, allergy and other respiratory diseases. Like many other magacities in the world the ambient air quality of Kolkata is also being deteriorated day by day. Automobile exhausts and certain industrial pollutants produce O_3 by photochemical reactions. The particulate matter, particularly less than 10 μm in size, can pass through the natural protective mechanism of human respiratory system and plays an important role in genesis and augmentation of allergic disorders. Sources of air pollution in the area and the unique problem arising out of the emission from the vehicles, industries, etc. have been described. Ambient air quality was monitored along with micrometeorological data and the results are discussed. The status of air pollution in the area has been evaluated and a questionnaire survey was conducted to estimate the allergic symptoms and exposure to assess the respiratory disorders. The data are analysed to evaluate the critical situation arising out of the emission of air pollutants and the impact on human health due to respirable diseases (RDs) to middle class sub-population (activity-wise) in the area are assessed. A strategic air quality management plan has been proposed. For the mitigation of air pollution problems in the city, the different measures to be adopted to maintain the balance between sustainable development and environmental management have been discussed.
(Ghose, Paul and Banerjee 2005)

Title: Air pollution–associated changes in lung function among asthmatic children in Detroit	
Year: 2005	**Author:** Lewis, T.C. *et. al.*
Commissioning Agency: Natl. Inst. Environ. Health Sciences/United States EPA	

Study Details:

Study Location: Michigan, USA	**Study Design:** Prospective Cohort study
Fossil Fuel Type: Coal	
Chemicals of Interest: O_3, $PM_{2.5}$, PM_{10}	

Abstract:

In a longitudinal cohort study of primary-school–age children with asthma in Detroit, Michigan, we examined relationships between lung function and ambient levels of particulate matter ≤ 10 μm and ≤ 2.5 μm in diameter (PM_{10} and $PM_{2.5}$) and ozone at varying lag intervals using generalized estimating equations. Models considered effect modification by maintenance corticosteroid (CS) use and by the presence of an upper respiratory infection (URI) as recorded in a daily diary among 86 children who participated in six 2-week seasonal assessments from winter 2001 through spring 2002. Participants were predominantly African American from families with low income, and > 75% were categorized as having persistent asthma. In both single-pollutant and two-pollutant models, many regressions demonstrated associations between higher exposure to ambient pollutants and poorer lung function (increased diurnal variability and decreased lowest daily values for forced expiratory volume in 1 sec) among children using CSs but not among those not using CSs, and among children reporting URI symptoms but not among those who did not report URIs. Our findings suggest that levels of air pollutants in Detroit, which are above the current National Ambient Air Quality Standards, adversely affect lung function of susceptible asthmatic children.
(Lewis, et al. 2005)

Title: Health impacts from power plant emissions in Mexico	
Year: 2005	**Author:** Lopez, M.T. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Mexico	**Study Design:** Modelling study
Fossil Fuel Type: Fuel oil	
Chemicals of Interest: NO_X, $PM_{2.5}$, SO_2	

Abstract:

Emissions from power plant pose a potentially large risk to human health and the environment. This pollution source is of particular concern in Mexico, where a large share of electricity is generated by the burning of high-sulfur fuel oil. In this paper, we estimate the health impacts due to air pollution from one of the Mexico's largest power plants, Tuxpan, located on the eastern coast. We calculate the annual average concentrations of primary and secondary (sulfates and nitrates) particulate matter, by modeling representative periods during the year 2001 using the CALPUFF–CALMET modeling system. We find that emissions from the power plant resulted in annual average concentrations of 0.12 μg m^{-3} (min–max: 0.00–1.43) for primary $PM_{2.5}$, 0.64 μg m^{-3} (0.01–2.84) for secondary PM2.5 and 3.09 μg m^{-3} (0.01–41.54) for SO_2 in the 120 km x120 km modeling domain. Such concentrations, while mostly affecting a relatively rural area, could result in significant public health and economic impacts for the local population. It is important to consider such damages when evaluating different electricity generation and control technologies.
(Lopez, et al. 2005)

Title: Diabetes enhances vulnerability to particulate air pollution–associated impairment in vascular reactivity and endothelial function	
Year: 2005	**Author:** O'Neill, M.S. *et. al.*
Commissioning Agency: National Institute of Environmental Health Sciences	

Study Details:

Study Location: Massachusetts, USA	**Study Design:** Cohort study
Fossil Fuel Type: Coal	
Chemicals of Interest: $PM_{2.5}$, black carbon, SO_4^{2-}	

Abstract:

Background—Epidemiological studies suggest that people with diabetes are vulnerable to cardiovascular health effects associated with exposure to particle air pollution. Endothelial and vascular function is impaired in diabetes and may be related to increased cardiovascular risk. We examined whether endothelium-dependent and -independent vascular reactivity was associated with particle exposure in individuals with and without diabetes.

Methods and Results—Study subjects were 270 greater-Boston residents. We measured 24-hour average ambient levels of air pollution (fine particles [$PM_{2.5}$], particle number, black carbon, and sulfates [SO_4^{2-}]) ≈500 m from the patient examination site. Pollutant concentrations were evaluated for associations with vascular reactivity. Linear regressions were fit to the percent change in brachial artery diameter (flow mediated and nitroglycerin mediated), with the particulate pollutant index, apparent temperature, season, age, race, sex, smoking history, and body mass index as predictors. Models were fit to all subjects and then stratified by diagnosed diabetes versus at risk for diabetes. Six-day moving averages of all 4 particle metrics were associated with decreased vascular reactivity among patients with diabetes but not those at risk. Interquartile range increases in SO_4^{2-} were associated with decreased flow-mediated (-10.7%; 95% CI, -17.3 to -3.5) and nitroglycerin-mediated (-5.4%; 95% CI, -10.5 to -0.1) vascular reactivity among those with diabetes. Black carbon increases were associated with decreased flow-mediated vascular reactivity (-12.6%; 95% CI, -21.7 to -2.4), and $PM_{2.5}$ was associated with nitroglycerin-mediated reactivity (-7.6%; 95% CI, -12.8 to -2.1). Effects were stronger in type II than type I diabetes.

Conclusions—Diabetes confers vulnerability to particles associated with coal-burning power plants and traffic.

(O'Neill, et al. 2005)

Title: Fine particles and meteorological conditions are associated with lung function in children with asthma living near two power plants	
Year: 2005	**Author:** Peled, R. *et. al.*
Commissioning Agency: Israel Electric Company/Town Association for Environmental Protection Ashkelon and Ashdod/Israel Lung Association	

Study Details:

Study Location: Israel	**Study Design:** Nested cohort study
Fossil Fuel Type: Coal, Oil	
Chemicals of Interest: $PM_{2.5}$, PM_{10}	

Abstract:

Fine particles are thought to pose a risk to health, especially for vulnerable groups such as children with asthma. These children are also known to be affected by meteorological and seasonal changes. We assessed the association between air pollution and lung function via peak expiratory flow (PEF), controlling for seasonal changes, meteorological conditions and personal physiological, clinical and sociodemographic measurements, in a panel of schoolchildren with asthma living near two power plants in Israel. Two hundred and eighty-five children with confirmed asthma performed PEF tests and completed a respiratory symptoms diary twice a day. Particulate matter <10 μm in diameter (PM_{10}), particulate matter <2.5 μm in diameter ($PM_{2.5}$) and meteorological conditions were measured at six fixed stations. Data were analysed using time series analysis—generalized linear model and generalized estimating equations. The models were built under the assumption that any health outcome belongs to a multivariate hierarchical system and depends on meteorological, geophysical and sociocultural variables and pollution factors. No significant differences were found in the demographic (age, gender, mean parental education level, parental smoking habits, place of birth and housing density), physiological (body mass index) and clinical factors (illness severity) between the communities participating in the study. A significant direct effect of $PM_{2.5}$ on the PEF was found in Ashdod (P=0.000). In Sderot, this effect was through an interaction between PM_{10} and the sequential day of the year (P=0.000). The main conclusion of this study is that children with asthma are at risk from air pollution and geophysical conditions. Policy makers should take these results into consideration when setting thresholds for environmental protection.
(Peled, et al. 2005)

Title: Public health and economic consequences of methyl mercury toxicity to the developing brain	
Year: 2005	**Author:** Trasande, L. *et. al.*
Commissioning Agency: National Institute of Environmental Health Sciences	

Study Details:

Study Location: United States	**Study Design:** Cost analysis study
Fossil Fuel Type: Coal	
Chemicals of Interest: Hg, MeHg (Methylmercury)	

Abstract:

Methyl mercury is a developmental neurotoxicant. Exposure results principally from consumption by pregnant women of seafood contaminated by mercury from anthropogenic (70%) and natural (30%) sources. Throughout the 1990s, the U.S. Environmental Protection Agency (EPA) made steady progress in reducing mercury emissions from anthropogenic sources, especially from power plants, which account for 41% of anthropogenic emissions. However, the U.S. EPA recently proposed to slow this progress, citing high costs of pollution abatement. To put into perspective the costs of controlling emissions from American power plants, we have estimated the economic costs of methyl mercury toxicity attributable to mercury from these plants. We used an environmentally attributable fraction model and limited our analysis to the neurodevelopmental impacts—specifically loss of intelligence. Using national blood mercury prevalence data from the Centers for Disease Control and Prevention, we found that between 316,588 and 637,233 children each year have cord blood mercury levels > 5.8 μg/L, a level associated with loss of IQ. The resulting loss of intelligence causes diminished economic productivity that persists over the entire lifetime of these children. This lost productivity is the major cost of methyl mercury toxicity, and it amounts to $8.7 billion annually (range, $2.2–43.8 billion; all costs are in 2000 US$). Of this total, $1.3 billion (range, $0.1–6.5 billion) each year is attributable to mercury emissions from American power plants. This significant toll threatens the economic health and security of the United States and should be considered in the debate on mercury pollution controls.
(Trasande, Landrigan and Schechter 2005)

Title: Inhibition of progesterone receptor activity in recombinant yeast by soot from fossil fuel combustion emissions and air particulate materials	
Year: 2005	**Author:** Wang, J. *et. al.*
Commissioning Agency: National Natural Science Foundation of China/Germany Federal Ministry of Education and Research	

Study Details:

Study Location: China	**Study Design:** *in vitro* study
Fossil Fuel Type: Coal	
Chemicals of Interest: Dust	

Abstract:

Numerous environmental pollutants have been detected for estrogenic activity by interacting with the estrogen receptor, but little information is available about their interactions with the progesterone receptor. In this study, emission samples generated by fossil fuel combustion (FFC) and air particulate material (APM) collected from an urban location near a traffic line in a big city of China were evaluated to interact with the human progesterone receptor (hPR) signaling pathway by examining their ability to interact with the activity of hPR expressed in yeast. The results showed that the soot of a petroleum-fired vehicle possessed the most potent anti-progesteronic activity, that of coal-fired stove and diesel fired agrimotor emissions took the second place, and soot samples of coal-fired heating work and electric power station had lesser progesterone inhibition activity. The anti-progesteronic activity of APM was between that of soot from petroleum-fired vehicle and soot from coal-fired establishments and diesel fired agrimotor. Since there was no other large pollution source near the APM sampling sites, the endocrine disrupters were most likely from vehicle emissions, tire attrition and house heating sources. The correlation analysis showed that a strong relationship existed between estrogenic activity and anti-progesteronic activity in emissions of fossil fuel combustion. The discoveries that some environmental pollutants with estrogenic activity can also inhibit hPR activity indicate that further studies are required to investigate potential mechanisms for the reported estrogenic activities of these pollutants.
(Wang, et al. 2005)

Title: **Comparison of arsenic levels in fingernails with urinary As species as biomarkers of arsenic exposure in residents living close to a coal-burning power plant in Prievidza District, Slovakia**	
Year: 2005	**Author:** Wilhelm,M. *et. al.*
Commissioning Agency: European Commission	

Study Details:

Study Location: Slovakia	**Study Design:** Case-control study
Fossil Fuel Type: Coal	
Chemicals of Interest: As	

Abstract:

The associations between As levels in fingernails with both As concentrations in urine and environmental samples are reported. The participants (aged 20–80 years, mean 66 years) lived in the vicinity of a coal-burning power plant with high As emissions in the Prievidza District, Slovakia. Samples were taken in 1999 and 2000. The As levels in fingernails (n=524) were measured after washing and digestion with microwave heating by hydride generation atomic absorption spectrometry. The spot urine samples (n = 436) were speciated for inorganic As (As_{inorg}), monomethylarsonic (MMA) and dimethylarsinic acid (DMA) by hydride-cryogenic trap-atomic absorption spectrometry. The geometric mean As level in fingernails was 0.10 μg/g (range, <0.01– 2.94 μg/g). There was a clear association between As in fingernails and the distance of the home to the power plant (P<0.001). Geometric mean As levels were: 0.17 μg/g distance ≤ 5 km, 0.10 μg/g 6–10 km and 0.08 μg/g > 10km. The association between the distance to the power plant and total urinary As (As_{sum}) (n=436, no fish consumption during the last 3 days before sample collection) was less pronounced (P=0.018). The As levels in fingernails were positively correlated to As in soil (n=207, r=0.23, P<0.001) and to As in house dust (n=209, r=0.30, P<0.001). The associations between urinary As_{sum} and As concentrations in soil (n=159, r=0.13, P<0.105) and in house dust (n=162, r=0.14, P<0.081) were quite similar. As levels in fingernails were associated with urinary As_{sum} and with the different As species in urine. It is concluded that As levels in fingernails are a reliable marker of environmental As exposure, and that As concentrations in fingernails reflect the As exposure in a similar manner compared with urinary As_{sum} and As species.
(Wilhelm, et al. 2005)

Title: Sustainability metrics for coal power generation in Australia	
Year: 2006	**Author:** Diniz da Costa, J.C. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Australia	**Study Design:** Modelling study
Fossil Fuel Type: Coal	
Chemicals of Interest: NO_X, $PM_{10,}$ SO_X	

Abstract:

The basis of this work was to investigate the relative environmental impacts of various power generators knowing that all plants are located in totally different environments and that different receptors will experience different impacts. Based on IChemE sustainability metrics paradigm, we calculated potential environmental indicators (PEI) that represent the environmental burden of masses of potential pollutants discharged into different receiving media. However, a PEI may not be of significance, as it may not be expressed at all in different conditions, so to try and include some receiver significance we developed a methodology to take into account some specific environmental indicators (SEI) that refer to the environmental attributes of a specific site. In this context, we acquired site specific environmental data related to the airsheds and water catchment areas in different locations for a limited number of environmental indicators such as human health (carcinogenic) effects, atmospheric acidification, photochemical (ozone) smog and eutrophication. The SEI results from this particular analysis show that atmospheric acidification has highest impact value while health risks due to fly ash emissions are considered not to be as significant. This is due to the fact that many coal power plants in Australia are located in low population density air sheds. The contribution of coal power plants to photochemical (ozone) smog and eutrophication were not significant. In this study, we have considered emission related data trends to reflect technology performance (e.g., PEI indicators) while a real sustainability metric can be associated only with the specific environmental conditions of the relevant sites (e.g., SEI indicators).
(Diniz da Costa and Pagan 2006)

Title: Assessment of public health risks associated with atmospheric exposure to $PM_{2.5}$ in Washington, DC, USA	
Year: 2006	**Author:** Greene, N.A. *et. al.*
Commissioning Agency: Howard University Program in Atmospheric Sciences/NOAA Center for Atmospheric Sciences	

Study Details:

Study Location: District of Columbia, USA	**Study Design:** Cohort study
Fossil Fuel Type: Not stated	
Chemicals of Interest: $PM_{2.5}$, Heavy metals in $PM_{2.5}$	

Abstract:

Abstract: In this research, we investigated the public health risks associated with atmospheric exposure to $PM_{2.5}$ for different subpopulations (black, white, Hispanic, youth, adults, and elderly) in the Washington, DC area. Washington, DC has long been considered a non-healthy place to live according to the American Lung Association due to its poor air quality. This recognition clearly includes the negative PM-related human health effects within the region. Specifically, DC fine particulate matter ($PM_{2.5}$) [or particulate matter with an aerodynamic diameter less than 2.5 μm] poses notable health risks to subpopulations having an annual mean value of 16.70 $\mu g/m^3$ during the years 1999-2004, exceeding the EPA National Ambient Air Quality Standard (NAAQS) of 15 $\mu g/m^3$. Incessant exposure to significant levels of PM has previously been linked to deleterious health effects, such as heart and lung diseases. The environmental quality and public health statistics of Washington, DC indicate the need for higher-resolution measurements of emissions, both spatially and temporally, and increased analysis of PM-related health effects. Our findings show that there are significant risks of ward-specific pediatric asthma emergency room visits (ERV). Results also illustrate lifetime excess lung cancer risks, exceeding the $1x10^{-6}$ threshold for the measured levels of particulate matter and heavy metals (chromium and arsenic) on behalf of numerous subpopulations in the DC selected wards.
(Greene and Morris 2006)

Title: GSTM1 and CYP1A1 polymorphisms, tobacco, air pollution,and lung cancer: A study in rural Thailand	
Year: 2006	**Author:** Pisani, P. *et. al.*
Commissioning Agency: Electricity Generating Authority of Thailand/Cancer Research UK	

Study Details:

Study Location: Thailand	**Study Design:** Case-control study
Fossil Fuel Type: Coal	
Chemicals of Interest: NO_2, SO_2, Total suspended particulates	

Abstract:

Objectives: The Lampang Province is situated in the northern region of Thailand. Incidence rates of lung cancer are high for Asian standards, particularly in women. This study was conducted to quantify the risk of lung cancer associated with exposures prevalent in the area and to investigate possible interactions with genetic susceptibility. The presence of several large open-cast coal mines from 1955 close to electricity-generating plants was a particular focus of concern.

Methods: Two-hundred and eleven cases of primary lung cancers diagnosed in 1993 to 1995 and residents in the province were recruited at the Lampang Provincial Hospital (main referral center for treatment of the disease). Two sets of controls, frequency-matched to the cases by sex and age, were recruited (a) from the resident population (202 interviewed) and (b) from patients admitted to the hospital for diseases predominantly unrelated to tobacco smoking (211 interviewed). Sociodemographic information, complete residential history, and characteristics of the household (place of cooking, cooking fuel, and heating fuels), occupational history, and history of tobacco smoking were obtained by interview. Cases and controls (~50% of the population based series) provided a blood sample. A point source air pollution exposure index was calculated for each village/township reported in residential histories based on the linear distance from the Mae Moh Center (the area of the electricity-generating plants), the year-specific gaseous (SO_2 and NO_2) or total suspended particulate emissions from the Mae Moh Power Plant, and the percentage of wind from the center. Odds ratios (OR) for the disease associated with categorical variables were estimated within unconditional logistic regression. Extraction of genomic DNA and genotyping of variants in CYP1A1 and GSTM1 were conducted to assess the extent of modification of risk by these genes that are involved in the metabolism of polycyclic aromatic hydrocarbons, a common component of the exposures.

Results: Overall, there was no evidence of relevant differences in the socioeconomic level of the three groups. The two control sets were similar with respect to lifelong tobacco habit and were subsequently pooled in analyses. Never smokers were 7% of men and 33% of women. Smoking of local traditional products unfiltered and high in tar content is a common habit in the rural female population. ORs associated with smoking increased with duration of the habit and average daily amount, being 4.9 [95% confidence interval (95% CI), 2.5-9.7] for smokers of ≥7 cigarettes/d and 3.3

(95% CI, 1.7-6.2) for duration of 41 years or longer compared with nonsmokers. Smoking of local products was associated with an independent OR of 3.1 (95% CI, 1.7-5.6) adjusted for lifelong cumulative amount of tobacco smoked. Although most smokers had the habit for at least 16 years, the daily consumption was low compared with Western standards. Other potential sources of exposure to lung carcinogens (emission from the power-generating plants and domestic burning of coal and wood for cooking and heating) were not associated with increased risk of lung cancer. None of the three polymorphisms examined increased the risk of lung cancer or modified the risk associated with tobacco smoking.

Conclusion: In this rural population, 96% of male and 64% of female lung cancer incidence were explained by tobacco smoking. None of the potential sources of air pollution deriving from the combustion of coal and wood, or polymorphisms in the CYP1A1 gene or deletion of the GSTM1 had an effect on the risk of lung cancer, either together or separately.

(Pisani, et al. 2006)

Title: Acute pulmonary and systemic effects of inhaled coal fly ash particles in rats: Comparison to ambient environmental particles	
Year: 2006	**Author:** Smith, K.R. *et. al.*
Commissioning Agency: Health Effects Institute/US EPA/Natl. Inst. Occup. Health and Safety/Natl. Inst. Environmental Health Sciences	

Study Details:

Study Location: Utah, USA	**Study Design:** Animal toxicology study
Fossil Fuel Type: Bituminous coal	
Chemicals of Interest: PM_1, $PM_{2.5}$, Elements and components of PM	

Abstract:

Although primary particle emissions of ash from coal-fired power plants are well controlled, coal fly ash (CFA) can still remain a significant fraction of the overall particle exposure for some plant workers and highly impacted communities. The effect of CFA on pulmonary and systemic inflammation and injury was measured in male Sprague-Dawley rats exposed to filtered air or CFA for 4 h/day for 3 days. The average concentration of CFA particulate matter less than 2.5 μm ($PM_{2.5}$) was 1400 $\mu g/m^3$, of which 600 $\mu g/m^3$ was PM_1. Animals were examined 18 and 36 h postexposure. Chemical analysis of CFA detected silicon, calcium, aluminum, and iron as major components. Total number of neutrophils in bronchoalveolar lavage fluid (BALF) following exposure to CFA was significantly increased along with significantly elevated blood neutrophils. Exposure to CFA caused slight increases in macrophage inflammatory protein-2, and marked increases in transferrin in BALF. Interleukin-1b and total antioxidant potential in lung tissues were also increased in rats exposed to CFA. Histological examination of lung tissue demonstrated focal alveolar septal thickening and increased cellularity in select alveoli immediately beyond terminal bronchioles. These responses are consistent with the ability of CFA to induce mild neutrophilic inflammation in the lung and blood following short-term exposure at levels that could be occupationally relevant. However, when comparing the effects of CFA with those of concentrated ambient particles, CFA does not appear to have greater potency to cause pulmonary alterations. This study furthers our understanding of possible mechanisms by which specific sources of particulate air pollution affect human health.
(Smith, et al. 2006)

Title: PAH–DNA adducts in cord blood and fetal and child development in a Chinese cohort	
Year: 2006	**Author:** Tang, D. *et. al.*
Commissioning Agency: National Institute of Environmental Health Sciences / US EPA / New York Community Trust	

Study Details:

Study Location: China	**Study Design:** Retrospective cohort study
Fossil Fuel Type: Coal	
Chemicals of Interest: Polycyclic aromatic hydrocarbons (PAHs)	

Abstract:

Polycyclic aromatic hydrocarbons (PAHs) are an important class of toxic pollutants released by fossil fuel combustion. Other pollutants include metals and particulate matter. PAH–DNA adducts, or benzo[a]pyrene (BaP) adducts as their proxy, provide a chemical-specific measure of individual biologically effective doses that have been associated with increased risk of cancer and adverse birth outcomes. In the present study we examined the relationship between prenatal PAH exposure and fetal and child growth and development in Tongliang, China, where a seasonally operated coal-fired power plant was the major pollution source. In a cohort of 150 nonsmoking women and their newborns enrolled between 4 March 2002 and 19 June 2002, BaP–DNA adducts were measured in maternal and umbilical cord blood obtained at delivery. The number of gestational months occurring during the period of power plant operation provided a second, more general measure of exposure to plant emissions, in terms of duration. High PAH–DNA adduct levels (above the median of detectable adduct level) were associated with decreased birth head circumference ($p = 0.057$) and reduced children's weight at 18 months, 24 months, and 30 months of age ($p < 0.05$), after controlling for potential confounders. In addition, in separate models, longer duration of prenatal exposure was associated with reduced birth length ($p = 0.033$) and reduced children's height at 18 ($p = 0.001$), 24 ($p < 0.001$), and 30 months of age ($p < 0.001$). The findings suggest that exposure to elevated levels of PAHs, with the Tongliang power plant being a significant source, is associated with reduced fetal and child growth in this population.
(Tang, et al. 2006)

Title: Applying cost analyses to drive policy that protects children	
Year: 2006	**Author:** Trasande, L. *et. al.*
Commissioning Agency: National Institute of Environmental Health Sciences	

Study Details:

Study Location: United States	**Study Design:** Cost analysis study
Fossil Fuel Type: Coal	
Chemicals of Interest: Hg, MeHg (Methylmercury)	

Abstract:

Exposure in prenatal life to methylmercury (MeHg) has become the topic of intense debate in the United States after the Environmental Protection Agency (EPA) announced a proposal in 2004 to reverse strict controls on emissions of mercury from coal-fired power plants that had been in effect for the preceding 15 years. This proposal failed to incorporate any consideration of the health impacts on children that would result from increased mercury emissions. We assessed the impact on children's health of industrial mercury emissions and found that between 316,588 and 637,233 babies are born with mercury-related losses of cognitive function ranging from 0.2 to 5.13 points. We calculated that decreased economic productivity resulting from diminished intelligence over a lifetime results in an aggregate economic cost in each annual birth cohort of $8.7 billion annually (range: $0.7–$13.9 billion, 2000 dollars). $1.3 billion (range: $51 million–$2.0 billion) of this cost is attributable to mercury emitted from American coal-fired power plants. Downward shifts in intellectual quotient (IQ) are also associated with 1566 (range: 115–2675) excess cases of mental retardation (MR defined as IQ<70) annually. This number accounts for 3.2% (range: 0.2–5.4%) of MR cases in the United States. If the lifetime excess cost of a case of MR (excluding individual productivity losses) is $1,248,648 in 2000 dollars, then the cost of these excess cases of MR is $2.0 billion annually (range: $143 million–$3.3 billion). Preliminary data suggest that more stringent mercury policy options would prevent thousands of cases of MR and billions of dollars over the next 25 years.
(Trasande, et al. 2006a)

Title: Mental retardation and prenatal methylmercury toxicity	
Year: 2006	**Author:** Trasande, L. *et. al.*
Commissioning Agency: Not stated (National Institute of Environmental Health Sciences?)	

Study Details:

Study Location: United States	**Study Design:** Modelling study
Fossil Fuel Type: Coal	
Chemicals of Interest: Hg, MeHg (Methylmercury)	

Abstract:

Background: Methylmercury (MeHg) is a developmental neurotoxicant; exposure results principally from consumption of seafood contaminated by mercury (Hg). In this analysis, the burden of mental retardation (MR) associated with methylmercury exposure in the 2000 U.S. birth cohort is estimated, and the portion of this burden attributable to mercury (Hg) emissions from coal-fired power plants is identified.

Methods: The aggregate loss in cognition associated withMeHg exposure in the 2000U.S. birth cohort was estimated using two previously published dose-response models that relate increases in cord blood Hg concentrations with decrements in IQ. MeHg exposure was assumed not to be correlated with native cognitive ability. Previously published estimates were used to estimate economic costs of MR caused by MeHg.

Results: Downward shifts in IQ resulting from prenatal exposure to MeHg of anthropogenic origin are associated with 1,566 excess cases of MR annually (range: 376–14,293). This represents 3.2% of MR cases in the US (range: 0.8%–29.2%). The MR costs associated with decreases in IQ in these children amount to $2.0 billion/year (range: $0.5–17.9 billion). Hg from American power plants accounts for 231 of the excess MR cases/year (range: 28–2,109), or 0.5% (range: 0.06%–4.3%) of all MR. These cases cost $289 million (range: $35 million–2.6 billion).

Conclusions: Toxic injury to the fetal brain caused by Hg emitted from coal-fired power plants exacts a significant human and economic toll on American children.

(Trasande, et al. 2006b)

Title: **Assessment of the impacts on health due to the emissions of Cuban power plants that use fossil fuel oils with high content of sulfur. Estimation of external costs**	
Year: 2007	**Author:** Carbonell, L.T. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Cuba	**Study Design:** Modelling study
Fossil Fuel Type: Fuel oil, Domestic crude oil	
Chemicals of Interest: NH_3, NO_X, PM_{10}, SO_X	

Abstract:

Fossil fuel electricity generation has been demonstrated to be a main source of atmospheric pollution. The necessity of finding out a balance between the costs of achieving a lower level of environmental and health injury and the benefits of providing electricity at a reasonable cost have lead to the process of estimating the external costs derived from these impacts and not included in the electricity prices as a quantitative measure of it that, even when there are large uncertainties involved, can be used by decision makers in the process of achieving a global sustainable development. The external costs of the electricity generation in three Cuban power plants that use fossil fuel oils with high sulfur content have been assessed. With that purpose a specific implementation of the Impact Pathways Methodology for atmospheric emissions was developed. Dispersion of atmospheric pollutants is modeled at local and regional scales in a detailed way. Health impacts include mortality and those morbidity effects that showed relation with the increment of selected pollutant concentration in national studies. The external cost assessed for the three plants was 40,588,309 USD yr^{-1} (min./max.: 10,194,833/169,013,252), representing 1.06 USD Cent kWh^{-1}. Costs derived from sulfur species (SO_2 and sulfate aerosol) stand for 93% of the total costs. (Carbonell, et al. 2007)

Title: **Low-carbon energy policy and ambient air pollution in Shanghai, China: A health-based economic assessment**	
Year: 2007	**Author:** Chen, C. *et. al.*
Commissioning Agency: US Energy Foundation	

Study Details:

Study Location: China	**Study Design:** Modelling study
Fossil Fuel Type: Coal, Gas	
Chemicals of Interest: PM_{10}, SO_2	

Abstract:

Energy and related health issues are of growing concern worldwide today. To investigate the potential public health and economic impact of ambient air pollution under various low-carbon energy scenarios in Shanghai, we estimated the exposure level of Shanghai residents to air pollution under various planned scenarios, and assessed the public health impact using concentration-response functions derived from available epidemiologic studies. We then estimated the corresponding economic values of the health effects based on unit values for each health outcome. Our results show that ambient air pollution in relation to low-carbon energy scenarios could have a significant impact on the future health status of Shanghai residents, both in physical and monetary terms. Compared with the base case scenario, implementation of various low-carbon energy scenarios could prevent 2804–8249 and 9870–23,100 PM10-related avoidable deaths (mid-value) in 2010 and 2020, respectively. It could also decrease incidence of several relevant diseases. The corresponding economic benefits could reach 507.31–1492.33 and 2642.45–6192.11 million U.S. dollars (mid-value) in 2010 and 2020, respectively. These findings illustrate that a low-carbon energy policy will not only decrease the emission of greenhouse gases, but also play an active role in the reduction of air pollutant emissions, improvement of air quality, and promotion of public health. Our estimates can provide useful information to local decision-makers for further cost-benefit analysis.
(Chen, et al. 2007)

Title: Estimating the effect of air pollution from a coal-fired power station on the development of children's pulmonary function	
Year: 2007	**Author:** Dubnov, J. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Israel	**Study Design:** Cohort study
Fossil Fuel Type: Coal	
Chemicals of Interest: NO_X, SO_2	

Abstract:

Using geographical information systems (GIS) tools, the present study analyzed the association between children's lung function development and their long-term exposure to air pollution. The study covered the cohort of 1492 schoolchildren living in the vicinity of a major coal-fired power station in the Hadera sub-district of Israel. In 1996 and 1999, the children underwent subsequent pulmonary function tests (PFT) (forced vital capacity (FVC) and forced expiratory volume during the first second (FEV_1)), and the children's parents completed a detailed questionnaire on their health status and household characteristics. A negative association was found between changes in the results of PFT and the estimated individual levels of air pollution. A sensitivity test revealed a FEV_1 decline from -4.3% for the average pollution level to -10.2% for the high air pollution level. The results of a sensitivity test for FVC were found to be similar. Association with the reported health status was found to be insignificant. As we conclude, air pollution from a coal-fired power station, although not exceeding local pollution standards, had a negative effect on children's lung function development. As argued, previous studies carried out in the region failed to show the above association because they were based on zone approaches that assign average concentration levels of air pollutants to all individuals in each zone, leading to a misclassification bias of individual exposure.
(Dubnov, et al. 2007)

Title: Comparative toxicity of size-fractionated airborne particulate matter obtained from different cities in the United States	
Year: 2007	**Author:** Gilmour, M.I. *et. al.*
Commissioning Agency: Environmental Protection Agency	

Study Details:

Study Location: United States (4 cities)	**Study Design:** Animal toxicology study
Fossil Fuel Type: Coal	
Chemicals of Interest: PM_{10}, $PM_{2.5}$, $PM_{0.1}$	

Abstract:

Hundreds of epidemiological studies have shown that exposure to ambient particulate matter (PM) is associated with dose-dependent increases in morbidity and mortality. While early reports focused on PM less than 10 μm (PM_{10}), numerous studies have since shown that the effects can occur with PM stratified into ultrafine (UF), fine (FI), and coarse (CO) size modes despite the fact that these materials differ significantly in both evolution and chemistry. Furthermore the chemical makeup of these different size fractions can vary tremendously depending on location, meteorology, and source profile. For this reason, high-volume three-stage particle impactors with the capacity to collect UF, FI, and CO particles were deployed to four different locations in the United States (Seattle, WA; Salt Lake City, UT; Sterling Forest and South Bronx, NY), and weekly samples were collected for 1 mo in each place. The particles were extracted, assayed for a standardized battery of chemical components, and instilled into mouse lungs (female BALB/c) at doses of 25 and 100 μg. Eighteen hours later animals were euthanized and parameters of injury and inflammation were monitored in the bronchoalveolar lavage fluid and plasma. Of the four locations, the South Bronx coarse fraction was the most potent sample in both pulmonary and systemic biomarkers, with a strong increase in lung inflammatory cells as well as elevated levels of creatine kinase in the plasma. These effects did not correlate with lipopolysaccharide (LPS) or total zinc or sulfate content, but were associated with total iron. Receptor source modeling on the $PM_{2.5}$ samples showed that the South Bronx sample was heavily influenced by emissions from coal fired power plants (31%) and mobile sources (22%). Further studies will assess how source profiles correlate with the observed effects for all locations and size fractions.
(Gilmour, et al. 2007)

Title: On ecological fallacy, assessment errors stemming from misguided variable selection, and the effect of aggregation on the outcome of epidemiological study	
Year: 2007	**Author:** Portnov, B.A. *et. al.*
Commissioning Agency: Not stated	

Study Details:

Study Location: Israel	**Study Design:** Ecological / Cohort studies
Fossil Fuel Type: Coal	
Chemicals of Interest: NO_X, SO_2	

Abstract:

In social and environmental sciences, ecological fallacy is an incorrect assumption about an individual based on aggregate data for a group. In the present study, the validity of this assumption was tested using both individual estimates of exposure to air pollution and aggregate data for 1,492 schoolchildren living in the in vicinity of a major coal-fired power station in the Hadera region of Israel. In 1996 and 1999, the children underwent subsequent pulmonary function tests (PFT), and their parents completed a detailed questionnaire on their health status and housing conditions. The association between children's PFT results and their exposure to air pollution was investigated in two phases. During the first phase, PFT averages were compared with average levels of air pollution detected in townships, and small census areas in which the children reside. During the second phase, individual pollution estimates were compared with individual PFT results, and pattern detection techniques (Getis-Ord statistic) were used to investigate the spatial data structure. While different levels of areal data aggregation changed the results only marginally, the choice of indices measuring the children's PFT performance had a significant influence on the outcome of the analysis. As argued, differences between individual-level and group-level effects of exposure (i.e., ecological or cross-level bias) are not necessary outcomes of data aggregation, and that seemingly unexpected results may often stem from a misguided selection of variables chosen to measure health effects. The implications of the results of the analysis for epidemiological studies are discussed, and recommendations for public health policy are formulated.
(Portnov, Dubnov and Barchana 2007)

2.4.2 Grey Literature Reports

Title: Particulate-Related Health Impacts of Eight Electric Utility Systems	
Year: 2002	**Author:** Abt Associates
Commissioning Agency: Environmental Integrity Project	

Document Details:

Study Location: United States	**Document Type:** Report
Fossil Fuel Type: Coal, Gas, Oil	
Chemicals of Interest: PM	

Abstract:

Power plants are large emitters of sulfur dioxide (SO_2) and nitrogen oxides (NO_X), particularly in the Midwest, where power plants dominate air pollution emissions. Perhaps the most hazardous contribution of these gaseous air emissions is the formation of secondary fine particulate matter. Over the past decade, numerous studies have linked particulate matter (PM) to a wide range of adverse human health effects, ranging from premature death, hospital admissions and asthma attacks to chronic bronchitis.

This report estimates these adverse health effects, in particular focusing on those associated with particulate air pollution from eight electric utility systems. Exhibit ES-1 presents a map with the locations of the power plants in these eight systems.

The analysis begins with an estimate of ambient particulate matter levels in a business-as-usual "baseline" scenario for 2007. This baseline assumes full implementation of the Acid Rain program and the U.S. Environmental Protection Agency's Summer Smog rule (the 1999 NO_X SIP Call). Using an efficient, reduced-form model, we estimated the change in ambient particulate matter from the baseline level by eliminating emissions from each system individually, as well as all eight systems together.

In examining the health impacts of ambient particulate matter attributable to these electric utility systems, we developed a range of concentration-response functions, including functions to estimate premature mortality, chronic bronchitis, hospital admissions and asthma attacks. Exhibit ES-2 presents the estimates that we derived for the impact of each system individually, as well as the eight systems together.

In any complex analysis using estimated parameters and inputs from numerous different models, there are likely to be many sources of uncertainty. This analysis is no exception. We used a variety inputs to derive the health effects estimates, including emission inventories, air quality models, epidemiological estimates of C-R functions, population estimates, and estimates of the future regulations, technology, and human behavior. Recognizing the existence of these uncertainties, we made conservative assumptions to the extent possible at all stages of the analysis, while still remaining consistent with the best available science.

(Abt Associates 2002a)

Title: Particulate-Related Health Impacts of Emissions in 2001 from 41 Major US Power Plants	
Year: 2002	**Author:** Abt Associates
Commissioning Agency: Environmental Integrity Project	

Document Details:

Study Location: United States	**Document Type:** Report
Fossil Fuel Type: Specific fossil fuel not stated	
Chemicals of Interest: NO_X, PM, SO_2	

Abstract:

Power plants are large emitters of sulfur dioxide (SO_2) and nitrogen oxides (NO_X), particularly in the Midwest, where power plants dominate emissions. Perhaps the most hazardous contribution of these gaseous emissions is through the formation of secondary fine particulate matter. Over the past decade, numerous studies have linked particulate matter (PM) to a wide range of adverse human health effects, ranging from premature death, hospital admissions and asthma attacks to chronic bronchitis. A substantial portions of the ambient levels of secondarily formed fine PM is formed from SO_2 and NO_X emissions from fossil fuel powered electricity generation, especially coal-fired power plants. The other major emission source that leads to the formation of ambient fine PM are mobile sources (cars and trucks), with other emission sources accounting for a smaller share of the total fine PM levels.

Since passage of the Clean Air Act Amendments of 1990, the amount of SO_2 emitted by power plants covered by Title IV (the "Acid Rain Bill") of the Clean Air Act has gone down by 32 percent (5.1 million tons). Although total US SO_2 emissions have gone nearly one third, not all individual power plants decreased their emissions by that much. Of the 608 power plants operating in both 1990 and 2001, 285 facilities increased their emissions, and 54 decreased their SO_2 emissions by less than 15 percent.

In a previous analysis for the Environmental Integrity Project, Abt Associates estimated the quantity of health effects attributable to fine PM formed from emissions from the major generating facilities of eight electricity generating companies. That analysis examined the health effects attributable to expected future levels of emissions from 83 power plants in the central and eastern United States. This previous study examined the emissions estimated to be released in 2007, after full implementation of all currently mandated major federal regulatory programs affecting electricity generation emissions. Another study Abt Associates prepared for the Clean Air Task Force also looked at 2007, examining the health impacts associated with all major power plants throughout the US. Instead of analyzing the health impacts in a future year (2007), this current report estimates these adverse health effects of the 2001 SO_2 and NO_X emissions from 41 major power plants.

(Abt Associates 2002b)

Title: Assessment of the health benefits of controlling air pollution in Shanghai, China	
Year: 2002	**Author:** Chang, Y-S. *et. al.*
Commissioning Agency: United States Department of Energy	

Study Details:

Study Location: China	**Study Design:** Modelling study
Fossil Fuel Type: Coal	
Chemicals of Interest: NO_X, $PM_{2.5}$, PM_{10}, SO_2, Total suspended particulates	

Abstract:

The large urban centers of the industrializing countries of the world are experiencing severe air quality problems as their demands for energy increase faster than their ability to afford strong environmental protection. This situation is particularly true in the fast-growing part of Asia, where coal often provides the fuel for power generation and industrial development and where the transportation sector grows unchecked. This paper describes the development of an integrated assessment of urban air quality and mitigation options for the city of Shanghai, China. First, a sector-specific, gridded inventory of emissions of SO2, NOx, and particulate matter (PM) is developed. PM is divided into three size categories (TSP, PM10, and PM2.5) and split into carbonaceous and mineral classes. The URBAT model, a non-steady-state Lagrangian puff model, and related techniques are used to determine the spatial distribution of ambient concentrations of primary and secondary pollutant species.

Damage functions are developed to determine the effects of these levels on human health in the greater Shanghai area. Two control scenarios are developed (for power generation and industry), and their effects on emissions of each species are estimated. The health benefits of the control measures are determined, and their relative costs are calculated. The result is a rudimentary cost-benefit analysis that can be used by urban and environmental planners as a guide for determining the relative effectiveness of taking different courses of action.

(Chang, et al. 2002)

Title: Health Impacts of Air Pollution from Washington DC Area Power Plants	
Year: 2002	**Author:** Clean Air Task Force
Commissioning Agency: Clean Air Task Force	

Document Details:

Study Location: DC, United States	**Document Type:** Report
Fossil Fuel Type: Coal, Oil	
Chemicals of Interest: $PM_{2.5}$	

Abstract:

For more than three decades, the nation's oldest and dirtiest power plants have avoided meeting tighter air pollution standards that new plants must meet. Power plants release a number of air pollutants, including soot-like particles known as fine particulate matter. Researchers at the Harvard School of Public Health examined the health impacts of fine particulate matter released by power plants near Washington DC. The study by Jonathan Levy, Susan Greco, and John Spengler examined five power plants: Benning, Chalk Point, Dickerson, Possum Point, and Potomac River. The key findings include:

• Over 250 deaths per year are linked to fine particulate matter from the five plants. Approximately 20 of these deaths are estimated to occur in Washington DC, 40 in Virginia, 60 in Maryland with the remainder occurring in nearby states. The impacts vary based upon the plant's size and proximity to population. Chalk Point was estimated to have the largest impact (about 100 deaths per year).

• If the five plants used readily available pollution control equipment, approximately 75% of the current deaths, asthma attacks, emergency room visits, and hospitalizations could be avoided.

• Disadvantaged groups are especially vulnerable to air pollution. Disadvantaged groups are more impacted from the five plants' emissions and receive more benefits from reducing their pollution than the population as a whole.

(Clean Air Task Force 2002)

Title: Technical Addendum: Methodologies for the Benefit Analysis of the Clear Skies Act of 2003	
Year: 2003	**Author:** Environmental Protection Agency
Commissioning Agency: Environmental Protection Agency	

Document Details:

Study Location: United States	**Document Type:** Report
Fossil Fuel Type: Specific fossil fuel type not stated	
Chemicals of Interest: Hg, NO_X, O_3, $PM_{2.5}$, SO_2	

Abstract:

On February 14, 2002, President Bush announced the Clear Skies Initiative, a proposal to reduce emissions from electric power generating sources. The proposal was embodied in legislative form as the Clear Skies Act of 2002, which was introduced in the House of Representatives and in the Senate in July 2002. The Clear Skies Act was reintroduced in the US House of Representatives (H.R. 999) and the US Senate (S. 485) as the Clear Skies Act of 2003 on February 27, 2003.

If enacted, the Clear Skies Act of 2003 would reduce emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_X), and mercury from fossil fuel-fired combustion units by approximately 70% from current levels at full implementation. These mandatory emission reductions would be achieved through a cap and trade program, modeled on the current Acid Rain Program for SO_2. Federally enforceable emissions limits, or national caps, for each pollutant would be established. Sources would be allowed to transfer these authorized emission limits among themselves to achieve the required reductions for all three pollutants at the lowest overall cost. This proposal would alleviate many of the remaining environmental and health problems associated with power generation.

This document reports the methods and results of an analysis of the environmental and health benefits of the Clear Skies Act of 2003. It presents quantitative estimates of the health improvements and monetary benefits that would be achieved by this proposal. (US EPA 2003)

Title: Assessing the Mercury Health Risks Associated With Coal-Fired Power Plants: Impacts of Local Depositions	
Year: 2003	**Author:** Sullivan, T.M. *et. al.*
Commissioning Agency: Brookhaven National Laboratory/US Dept. of Energy	

Document Details:

Study Location: PA, USA and TX, USA	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: Hg	

Abstract:

The U.S. Environmental Protection Agency has announced plans to regulate emissions of mercury to the atmosphere from coal-fired power plants. However, there is still debate over whether the limits should be placed on a nationwide or a plant-specific basis. Before a nationwide limit is selected, it must be demonstrated that local deposition of mercury from coal-fired power plants does not impose an excessive local health risk. The principal health concern is exposure of pregnant females to methyl mercury in seafood.

This paper presents a quantitative assessment of the health risks for populations within 50 km of a power plant. Probabilistic risk assessments were performed for two power plants, Bruce Mansfield in western Pennsylvania and Monticello in eastern Texas. Local hourly meteorological data was obtained for these sites and deposition modeling was performed for a region 50 Km around the site. Risk assessments were performed for two population groups (general and subsistence fishers) and the modeled deposition patterns. The risk assessments indicated that for the general population local deposition associated with the emissions from the coal-fired power plant were small (< 10-5 risk of observed neurological effects) but risks could be two orders of magnitude higher for subsistence fisher populations. Estimated risks were more highly dependent on consumption patterns than increases in deposition due to coal-fired power plant emissions.

(Sullivan, et al. 2003)

Title: Power Plant Emissions: Particulate Matter-Related Health Damages and the Benefits of Alternative Emission Reduction Scenarios	
Year: 2004	**Author:** Abt Associates
Commissioning Agency: Clean Air Task Force	

Document Details:

Study Location: United States	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: $PM_{2.5}$	

Abstract:

Power plants are significant emitters of sulfur dioxide (SO_2) and nitrogen oxides (NO_X). In many parts of the country, especially the Midwest, power plants are the largest contributors. These gases are harmful themselves, and they contribute to the formation of acid rain and particulate matter. Particulate matter (PM) reduces visibility, often producing a milky haze that blankets wide regions, and it is a serious public health problem. Over the past decade and more, hundreds of studies worldwide have linked particulate matter to a wide range of adverse health effects in people of all ages, including premature death, chronic bronchitis, hospital admissions and asthma. While this large body of research cannot establish a cause-and-effect relationship between PM and adverse health effects, the research does provide strong evidence that reducing ambient PM concentrations will lead to improvements in human health. The US EPA developed analytical methods that draw on this health research, combined with estimates of future air pollution emissions and air quality models, to prepare quantified estimates of the avoidable health effects from improving ambient PM levels. The EPA used these analytical methods to estimate the health benefits of a wide variety of actual or proposed individual federal air programs, including programs that reduce emissions from power plants, cars, and both on-road and off-road diesel engines.

This report estimates the avoidable health effects of each of a series of alternative regulatory scenarios for power plants, focusing on the adverse human health effects due to exposure to fine particulate matter ($PM_{2.5}$, which are particles less than 2.5 microns in diameter). This report uses the same analytical methods that the U.S. Environmental Protection Agency used in 2003 to prepare an analysis of the potential health effects of the proposed Clear Skies Act. This report conducts an analysis of the impacts in 2010 and 2020 of three policy alternatives to the proposed Clear Skies Act. In addition, this report also examines the health impacts associated with the total amount of emissions from coal fired electricity generating units (power plants) in 2010. This "No EGU" analysis is clearly not a policy option, but rather helps gain a better understanding of the total magnitude of the health effects associated with the total emissions from this major sources of pollutants that lead to the formation of PM. It also helps put into better context the health improvements associated with each of the policy option scenarios examined in this report.

(Abt Associates 2004)

Title: Air Pollution-Related Burden of Illness in Toronto: 2004 Update	
Year: 2004	**Author:** Pengelly, L.D. *et. al.*
Commissioning Agency: Toronto Public Health	

Document Details:

Study Location: Ontario, Canada	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: CO, NO_2, O_3, $PM_{2.5}$, SO_2	

Abstract:

In the last decade, there has been growing use of burden of illness estimates as an indicator of air quality impact at all levels of government (Federal, Provincial and Municipal), by nongovernmental agencies and community groups. Its greatest application seems to have been in the planning mode: to stimulate action; to address perceived errors; and to avoid harm from planned changes which will have environmental consequences. The population in general has noted that governments can be called into action much more by drawing attention to threats to community health than by focusing on adverse impacts on the natural environment. Thus to a properly educated and convinced community, the burden of illness study based on local air quality and health data, but using risk coefficients from the literature is a cost-effective and reliable approach to the problem of risk evaluation and risk communication.

Toronto Public Health has previously used the BOI methodology to estimate the air pollution related burden of illness for the City of Toronto associated with several criteria pollutants. The present work has been undertaken for two reasons: first, to update the scientific foundations of the previous study; and second, to assess the air pollution burden of illness related to the most recent measurements of air quality in Toronto.

We have examined the recent epidemiological literature, as well as recent reviews carried out for regulatory purposes, and have determined a set of coefficients of the air pollution-related burden of illness applicable to Toronto. We have also summarized recent quality-controlled air pollution data for several sites within the City, and have obtained baseline health outcome information in a form which can be linked to the air quality monitoring sites. Using this information, we have estimated the non-traumatic mortality associated with air pollution in Toronto for the year 1999, the most recent year for which there was adequate information. We have quantified the air pollution risk in the City of Toronto taking into account the most recent scientific evidence available, and have estimated that approximately 1700 premature deaths each year, and between 3000 and 6000 hospital admissions are associated with the criteria pollutants O_3, NO_2, SO_2,CO and PM_{10} breathed by the public at large.

In comparing this result to that previously obtained in a similar exercise in 2000, we find that in spite of substantial revisions to earlier studies which have tended to reduce the estimate of burden of illness of air pollution in urban centres, using the same

methods, the estimate of premature mortality as a result of the present work is consistent with the lower bound estimate of 700 premature deaths made in 2000, ignoring the impact of chronic exposure to particles. However, based on the much greater scientific strength of the revised and re-affirmed chronic exposure studies, we believe that a more supportable estimate of non-traumatic mortality attributable to air pollution in Toronto is 1700. The estimates of 3000 to 6000 excess hospital admissions in this update are consistent with the lower and upper bounds (3300 to 7600) of the estimate made in 2000.

New studies in the literature demonstrate the importance of focusing on susceptible groups: infants, children and the elderly. Rather than examining the effect of air pollution, pollutant by pollutant on the population as a whole, future studies should examine the role of the pollutant mix on susceptible groups, and to develop air quality management strategies aimed at the sources of the most toxic components of the pollutant mix.

The results of this estimation of the air pollution-related burden of illness in the City of Toronto shows that every year there is still a major public health cost attributable to criteria pollutants from fossil-fuel combustion in the City and beyond.

(Pengelly and Sommerfreund 2004)

Title: Cost Benefit Analysis: Replacing Ontario's Coal-Fired Electricity Generation	
Year: 2005	**Author:** DSS Management Consult. *et. al.*
Commissioning Agency: Ontario Ministry of Energy	

Document Details:

Study Location: Ontario, Canada	**Document Type:** Cost Benefit Analysis
Fossil Fuel Type: Coal	
Chemicals of Interest: O_3, $PM_{2.5}$	

Abstract:

Introduction: This report documents the methodology, data and results of an independent cost-benefit analysis (CBA) of the financial costs and health and environmental damages associated with four electricity generation scenarios. These scenarios cover a range of electricity generation alternatives for replacing the electricity produced by the province's coal-fired generation facilities. The results of this study provide an estimation of the costs and benefits of some of the policy directions available to the government of Ontario with respect to replacing the coal-fired generation facilities.

Four scenarios were identified by the Ministry of Energy, namely:
- Scenario 1 – Base Case (the status quo, continue operating the coal-fired generation facilities within the current regulatory regime1),
- Scenario 2 – All Gas (produce all of the replacement electricity through gas generation facilities constructed for this purpose alone),
- Scenario 3 – Nuclear/Gas (produce all of the replacement electricity through a combination of refurbished nuclear and new gas generation facilities constructed for this purpose alone), and
- Scenario 4 – Stringent Controls (continue operating the coal-fired generation facilities but install new emission control technology so that the best available control technology is in place).

The first step in this CBA was to estimate the financial costs (i.e., capital, operating, maintenance and fuel costs) of each scenario. The next step involved air quality modelling using projected emission profiles for each scenario. Next the health and environmental impacts of each scenario were estimated. Finally, the corresponding monetary value of these impacts was estimated. By summing the financial costs and monetary health and environmental damages, the total cost of generation for each scenario was estimated. The net benefit for each of the three scenarios relative to the base case was calculated by taking the difference in the total cost of generation.

Conclusion: The results of this analysis suggest that Scenario 3 (Nuclear/Gas) is likely to yield the greatest net benefit of the four scenarios analysed. This conclusion is insensitive to the values assigned to key parameters. While the net benefit estimates in

this report involve certain gaps and limitations, the results do provide insight into the expected relative performance of the scenarios. This insight is suitable to assist with making policy decisions concerning future electricity generation options for the province.

The results of this CBA are relevant to current initiatives by the provincial government. The government is actively pursuing a diverse range of generation technologies including refurbishing nuclear plants, increasing natural gas and renewable generation capacity, development of conservation programs and seeking contracts to import hydroelectric generation from other provinces. As new information becomes available in the future, further analysis will be able to refine the net benefits estimates associated with potential electricity generation alternatives.

(DSS Management Consultants Inc. and RWDI Air Inc. 2005)

Title: Transboundary Air Pollution in Ontario	
Year: 2005	**Author:** Yap, D. *et. al.*
Commissioning Agency: Ontario Ministry of the Environment	

Document Details:

Study Location: Ontario, Canada	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: O_3, $PM_{2.5}$	

Abstract:

A significant amount of Ontario's smog originates from emission sources in the United States (U.S.). Although data analysis strongly indicates that neighbouring U.S. states continue to be major contributors to elevated levels of ground-level ozone and fine particulate matter ($PM_{2.5}$), Ontario acknowledges and takes responsibility for its local emissions and its role as a contributor to the regional transport of air pollution.

This report provides a current review of transboundary air pollution impacts from an Ontario perspective. Drawing on Ontario's extensive air quality data, and recent air quality modelling work, the document examines the role of transboundary air pollution in Ontario, specifically the impacts of smog (both ground-level ozone and fine particulate matter) and an assessment of the human health and economic costs. The report also examines the impact of Ontario's emissions on other jurisdictions. Acid deposition and mercury impacts are reviewed as these are current and emerging regional air issues of concern to Ontarians and adjacent jurisdictions. Emission control programs, initiatives and agreements that are being undertaken or considered to address these transboundary problems are also highlighted.

(Yap, et al. 2005)

Title: Economic Valuation of Human Health Benefits of Controlling Mercury Emissions from U.S. Coal-Fired Power Plants	
Year: 2005	**Author:** Rice, G. *et. al.*
Commissioning Agency: Northeast States for Coordinated Air Use Management	

Document Details:

Study Location: United States	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: Hg	

Abstract:

Introduction: Previous studies that evaluated the impact of reducing mercury emissions from power plants either did not evaluate the potentially resultant changes in methylmercury exposure in the U.S. population (U.S. EPA, 2003b) or, if exposure was evaluated, were unable to adequately evaluate differences in sources of fish in U.S. diets (EPRI, 2003). Our goals were to characterize the impact that reductions in mercury emissions from power plants would have on methylmercury exposures in the U.S. population and to estimate quantitatively the economic benefit of the plausible improvements in the health of the U.S. population.

We investigate five U.S. mercury emissions scenarios. The first scenario is based on current mercury emissions, two scenarios are based on U.S. EPA projections of changes in mercury emissions that are projected to occur in 2010 and 2020 under current U.S. regulations (taking into account factors such as economic growth), and the final two are based on likely emissions if the CSI passes into law. To estimate the change in exposure, we identify eight geographic regions that are sources of consumable fish and estimate the quantity of fish from each region that is consumed, noting the current population exposures and the size of the consuming population. The impact of decreased mercury emissions from power plants on mercury deposition in these regions is estimated and related to decreases in methylmercury concentrations in these fish. Based on data that describe the types of fish consumed and current fish consumption rates, we estimate changes in methylmercury exposure in the U.S. population.

(Rice and Hammitt 2005)

Title: Mercury Emissions from Coal Fired Power Plants - Local Impacts on Human Health Risk	
Year: 2005	**Author:** Sullivan, T.M. *et. al.*
Commissioning Agency: Brookhaven National Laboratory	

Document Details:

Study Location: United States	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: Hg	

Abstract:

Introduction: This report examines the possibility that coal-fired power plants act as local sources leading to mercury "hot spots", using a three-tiered approach. First, the worldwide literature was searched for reports of deposition around mercury sources, including coal-fired power plants. Second, soil samples from around two mid-sized U.S. coal-fired power plants were collected and analyzed for evidence of "hot spots" and for correlation with model predictions of deposition. Third, a risk assessment construct was developed that demonstrates a possible approach for examining human-health risks that might be associated with local deposition of mercury emitted from coal-fired power plants. Based on this work, conclusions about the impacts of "hot–spots" are made.

Conclusion: The major objective of this study was to determine if there was evidence for "hot-spots" of mercury deposition around coal-fired power plants. Although the term has been used extensively, it has never been defined. From a public health perspective, such a "hot spot" must be large enough to insure that it did not occur by chance, and it must affect water bodies large enough to support a population of subsistence fishers. The results of this study support the hypothesis that neither of these conditions has been met.

(Sullivan, et al. 2005)

Title: Health Consultation, Chauncey PCB Site, Review of EPA Sample Data for Nov 2003 Through Mar 2004, Chauncey, Logan County, West Virginia	
Year: 2005	**Author:** West Virginia DHHR
Commissioning Agency: West Virginia Dept. of Health and Human Resources/ATSDR	

Document Details:

Study Location: West Virginia, USA	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: As, Pb, Pesticides	

Abstract:

The Chauncey PCB Site (the site) involves various areas in and around the town of Chauncey, West Virginia, where residents suspect that dumping of chemicals has occurred in the past. The site is about 20 acres.

A health consultation completed on March 8, 2004, reviewed data from samples taken by the U.S. Environmental Protection Agency (EPA) in April 2003 and data from samples taken by West Virginia Department of Environmental Protection (WVDEP) in October and November 2003. The site was initially named the "Chauncey PCB Site" on the basis of Chauncey residents' concerns that PCBs were contaminating their community. After evaluating the available environmental data, West Virginia Department of Health and Human Resources (WVDHHR) concluded that PCBs were not found at this site in high enough amounts to be causing adverse health effects. The main exposure pathway that WVDHHR identified in the first health consultation was exposure to lead and arsenic from incidental ingestion of soil or sediment containing these chemicals. WVDHHR concluded that under the site-specific conditions of exposure at this site, chemicals in the samples posed no apparent public health hazard for the present or future. No historical data existed, so the site was classified as an indeterminate public health hazard for the past.

After the April 2003 sampling event, EPA took additional samples at this site because results of the previous sampling showed some contaminants present (though not at high enough levels to be likely to adversely affect health) where additional evaluation was prudent and because of community member concerns relating to dumping of pesticides in an area now used as ball fields for children. The additional sampling was done from November 2003 through March 2004. The results are reviewed in this health consultation, which evaluates the potential for adverse health effects occurring from exposures to the chemicals at the levels detected at this site.

(West Virginia Department of Health and Human Resources 2005)

Title: Wabamun and Area Community Exposure and Health Effects Assessment Program	
Year: 2006	**Author:** Alberta Health and Wellness
Commissioning Agency: Alberta Health and Wellness	

Document Details:

Study Location: Alberta, Canada	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: As, Hg, NO_2, O_3, SO_2, PAHs, $PM_{2.5}$, VOCs, Organic acids	

Abstract:

This report summarizes the results of a community exposure and health effects assessment undertaken in the Wabamun area to gauge the impact of airborne contaminants on the health of the population. The report describes the population and personal distribution of exposure to airborne chemicals and particulates in the Wabamun area. Using a personal exposure model, the relative contribution of various exposure sources and pathways to airborne chemicals is estimated and associations between exposure to airborne chemicals and human health effects are described.
(Alberta Health and Wellness 2006)

Title: Analysis of Particulate Matter Impacts for Six Power Plants in Maryland	
Year: 2006	**Author:** Levy, J.
Commissioning Agency: Not stated	

Document Details:

Study Location: Maryland, United States	**Document Type:** Report
Fossil Fuel Type: Specific fossil fuel not stated	
Chemicals of Interest: $PM_{2.5}$	

Abstract:

This report provides a detailed look at the influence of the six highest emitting power plants in Maryland on air pollution and health within the state and elsewhere, based on a previously published regional analysis and previous national-scale modeling efforts. The focus is on fine particulate matter ($PM_{2.5}$), since studies have shown that respiratory and cardiovascular health are likely affected by $PM_{2.5}$ at current outdoor levels in Maryland.

In this analysis, current emission rates of sulfur dioxide (SO_2), nitrogen oxides (NO_X), and directly-emitted (primary) $PM_{2.5}$ emissions were gathered for Brandon Shores, Chalk Point, C.P. Crane, Dickerson, Herbert A. Wagner, and Morgantown. Previous applications of either CALPUFF or a source-receptor matrix were used to model the impacts of these emissions on ambient concentrations of $PM_{2.5}$ over a large area around the plants. This information was then linked with evidence of the health effects of changes in air pollution levels, to arrive at an estimated public health impact.

The models determined that the six power plants combined contribute approximately 0.2-1.0 μg/m3 of annual average $PM_{2.5}$ in Maryland, with the impact varying across the state based on proximity to the various plants. While this only represents a fraction of current outdoor concentrations (approximately 12-17 μg/m3 on an annual average basis in Maryland in 2004), this increment may be significant in determining non-attainment status in some locations, and the public health impacts remain potentially important. Looking at each plant individually, the impacts typically exhibit spatial patterns in which the maximum concentration impact occurs in relatively close proximity to the power plant.

Considering health outcomes based on current population estimates, the six power plants together have an annual impact in Maryland of approximately 100 premature deaths, 4,000 asthma attacks, and over 100,000 person-days with minor restrictions in activity, among other health outcomes. The corresponding annual national impacts are approximately 700 deaths, 30,000 asthma attacks, and nearly 800,000 person-days with minor restrictions in activity. About 8-20% of the impacts of the six power plants occur in Maryland (which has 2% of the US population), indicating greater individual risks in Maryland but higher total public health burdens outside of the state than inside of the state.

These findings emphasize the importance of considering local, regional, and national sources of $PM_{2.5}$ when developing emission control strategies. It is also clear that

emission control decisions must consider regional impacts if total public health benefits are a concern, but must also evaluate local impacts to ensure that individuals or populations are not disproportionately impacted. These findings are not intended to provide specific policy recommendations, as these impacts were not compared with alternative technologies, nor were the costs of controlling these pollutants considered. However, these findings indicate that the six highest emitting power plants in Maryland may have an annual public health impact on the order of hundreds of millions of dollars in Maryland and billions of dollars nationally, emphasizing that further analysis might be warranted to determine the most appropriate public policy measures to adopt.
(Levy 2006)

Title: Premature Mortality from Proposed New Coal-fired Power Plants in Texas	
Year: 2006	**Author:** Public Citizen's Texas Office
Commissioning Agency: Sustainable Energy and Economic Development Coalition	

Document Details:

Study Location: Texas, United States	**Document Type:** Research brief
Fossil Fuel Type: Coal	
Chemicals of Interest: NO_X, SO_2	

Abstract:

Premature mortalities are among the well-documented public health impacts caused by air pollution. Sulfur dioxide (SO_2) and nitrogen oxide (NO_X) pollution in particular are dangerous, because both kinds contribute to the formation of microscopic air pollution particles, known as particulates, that can be drawn deeply into the lungs. The 19 coal-fired power plant units studied in this research brief will emit over 100,000 tons of these two pollutants every year. This pollution will cause 240 premature mortalities per year and nearly 12,000 premature mortalities over the expected lifetimes of the plants. As the company with the largest number of new coal units planned, TXU dominates these figures. Pollution from TXU's proposed new units can be expected to cause 177 premature mortalities per year, and 8,869 premature mortalities over the lifetimes of the units.

The U.S. Environmental Protection Agency uses a value of approximately $6 million per mortality when calculating the economic impact of policies. Using that value, the annual cost in mortality of the proposed plants is $1.4 billion per year. The cost over the expected lifetimes of the plants is nearly $72 billion.

(Public Citizen's Texas Office 2006)

Title: **Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA): Application to Power Plant-Derived $PM_{2.5}$. Topical Report: Plant 0 (Upper Midwest)**	
Year: 2006	**Author:** Rohr, A.
Commissioning Agency: Electric Power Research Inst./US Dept. of Energy	

Document Details:

Study Location: Southeastern United States	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: $PM_{2.5}$	

Abstract:

TERESA (Toxicological Evaluation of Realistic Emissions of Source Aerosols) involves exposing laboratory rats to realistic coal-fired power plant and mobile source emissions to help determine the relative toxicity of these PM sources. There are three coal-fired power plants in the TERESA program; this report describes the results of fieldwork conducted at the first plant, located in the Upper Midwest.

The project was technically challenging by virtue of its novel design and requirement for the development of new techniques. By examining aged, atmospherically transformed aerosol derived from power plant stack emissions, we were able to evaluate the toxicity of PM derived from coal combustion in a manner that more accurately reflects the exposure of concern than existing methodologies. TERESA also involves assessment of actual plant emissions in a field setting – an important strength since it reduces the question of representativeness of emissions.

A sampling system was developed and assembled to draw emissions from the stack; stack sampling conducted according to standard EPA protocol suggested that the sampled emissions are representative of those exiting the stack into the atmosphere. Two mobile laboratories were then outfitted for the study: (1) a chemical laboratory in which the atmospheric aging was conducted and which housed the bulk of the analytical equipment; and (2) a toxicological laboratory, which contained animal caging and the exposure apparatus. Animal exposures were carried out from May-November 2004 to a number of simulated atmospheric scenarios. Toxicological endpoints included (1) pulmonary function and breathing pattern; (2) bronchoalveolar lavage fluid cytological and biochemical analyses; (3) blood cytological analyses; (4) in vivo oxidative stress in heart and lung tissue; and (5) heart and lung histopathology.

Results indicated no differences between exposed and control animals in any of the endpoints examined. Exposure concentrations for the scenarios utilizing secondary particles (oxidized emissions) ranged from 70 - 256 $\mu g/m^3$, and some of the atmospheres contained high acidity levels (up to 49 $\mu g/m^3$ equivalent of sulfuric acid). However, caution must be used in generalizing these results to other power plants utilizing different coal types and with different plant configurations, as the emissions may vary based on these factors.

(Rohr 2006a)

Title: Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA): Application to Power Plant-Derived $PM_{2.5}$. Topical Report: Plant 1 (Southeast)	
Year: 2006	**Author:** Rohr, A.
Commissioning Agency: Electric Power Research Inst./US Dept. of Energy	

Document Details:

Study Location: Southeastern United States	**Document Type:** Report
Fossil Fuel Type: Coal	
Chemicals of Interest: $PM_{2.5}$	

Abstract:

TERESA (Toxicological Evaluation of Realistic Emissions of Source Aerosols) involves exposing laboratory rats to realistic coal-fired power plant and mobile source emissions to help determine the relative toxicity of these PM sources. There are three coal-fired power plants in the TERESA program; this report describes the results of fieldwork conducted at the second plant, located in the Southeastern United States.

The project was technically challenging by virtue of its novel design and requirement for the development of new techniques. By examining aged, atmospherically transformed aerosol derived from power plant stack emissions, we were able to evaluate the toxicity of PM derived from coal combustion in a manner that more accurately reflects the exposure of concern than existing methodologies. TERESA also involves assessment of actual plant emissions in a field setting – an important strength since it reduces the question of representativeness of emissions.

Seven sets of animal exposures were carried out from March-September 2005 to a number of simulated atmospheric scenarios. Toxicological endpoints included (1) pulmonary function and breathing pattern; (2) bronchoalveolar lavage fluid cytological and biochemical analyses; (3) blood cytological analyses; (4) in vivo oxidative stress in heart and lung tissue; (5) heart and lung histopathology; and (6) cardiac function via telemetry and electrocardiogram data collection.

Continuous exposure data collected included RH, temperature, PM mass (TEOM), ozone, NO, NO_2, SO_2, and particle count. Particle number concentrations were lowest (910 cm^{-3}) for the primary particle scenario (P) and highest (40,811 cm^{-3}) for the most complex neutralized scenario (PONS). Mass concentrations ranged from 13.9 $\mu g/m^3$ for the P scenario to 385 $\mu g/m^3$ for one of the oxidized emissions + SOA scenarios (POS). Substantial day-to-day variability was observed in PM2.5 mass concentrations, likely due to the inherent variation in the power plant operation. Concentrations of ozone, NO_X and SO_2 were below 50 ppb. Integrated measurements indicated that sulfate concentrations ranged from 82 to 175 $\mu g/m^3$, while nitrate was low in all scenarios except the neutralized scenario (PONS). Ammonium was similarly low in all scenarios except PONS. Higher-than-expected EC and OC concentrations are likely to be an artifact due to the use of filtered room air for flushing the denuders. Elemental data suggest substantial day-today variability in concentrations. All elements had low concentrations except for sulfur. Prominent among these were: Si, Br, Ca, K, La, and Cu. Few other elements were found to be present during specific exposure rounds.

Pulmonary function data suggest subtle changes in some respiratory parameters in some scenarios. The in vivo chemiluminescence (CL) dataset for Plant 1 suggests that both lung and heart oxidative stress occur in response to several scenarios. No changes in histology, bronchoalveolar lavage fluid, or blood cytology were evident. Stage II assessments conducted for the PONS scenario at Plant 1 suggest no apparent effect on heart rate or on several measures of heart rate variability. However, this scenario resulted in an increase in cardiac arrhythmias (premature ventricular beats; PVBs) in exposed animals compared to sham/control animals.
(Rohr 2006b)

Title: Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA): Application to Power Plant-Derived $PM_{2.5}$	
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Abstract:

This report documents progress made on the subject project during the period of September 1, 2007 through February 28, 2007. The TERESA Study is designed to investigate the role played by specific emissions sources and components in the induction of adverse health effects by examining the relative toxicity of coal combustion and mobile source (gasoline and/or diesel engine) emissions and their oxidative products. The study involves on-site sampling, dilution, and aging of coal combustion emissions at three coal-fired power plants, as well as mobile source emissions, followed by animal exposures incorporating a number of toxicological endpoints. The DOE-EPRI Cooperative Agreement (henceforth referred to as "the Agreement") for which this technical progress report has been prepared covers the performance and analysis of field experiments at the first TERESA plant, located in the Upper Midwest and henceforth referred to as Plant 0, and at two additional coal-fired power plants (Plants 1 and 2) utilizing different coal types and with different plant configurations. During this reporting period, fieldwork was completed at Plant 2, located in the Midwest.
(Rohr 2007)

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