PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

**Environmental and Water Resources**

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# ATMOSPHERIC AEROSOL SOURCE-RECEPTOR RELATIONSHIPS: THE ROLE OF COAL-FIRED POWER PLANTS

## PRIMARY PROJECT PARTNERS

**Carnegie Mellon University**
Pittsburgh, PA

**U. S. EPA**
Research Triangle Park, NC
(co-funding)

## PROJECT LOCATION

Pittsburgh, PA

## CUSTOMER SERVICE

800-553-7681

## WEBSITE

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## Background

Epidemiological research over the past 10 years has revealed a consistent statistical correlation between levels of airborne fine particulate matter ($PM_{2.5}$) and adverse human health effects. This has resulted in U.S. EPA's promulgation of National Ambient Air Quality Standards (NAAQS) that limit the allowable mass concentrations of $PM_{2.5}$. Data gathered since 1997 suggests that the region surrounding Pittsburgh, PA may have difficulty in meeting the NAAQS for $PM_{2.5}$. In order to develop a better understanding of this issue, the U.S. Department of Energy's National Energy Technology Laboratory (DOE-NETL) is sponsoring a multifaceted program designed to identify and quantify the current and future effects of coal-fired power plants on $PM_{2.5}$ in and around the upper Ohio River valley. By understanding the exact nature of the source-receptor relationships governing $PM_{2.5}$, the most cost-effective policies and strategies can be developed for achieving compliance with air quality regulations and improving human health. A key project in this effort is being performed by Carnegie-Mellon University (CMU) in cooperation with U.S. EPA and other major universities across the U.S.

## Objectives

The main objectives of this project are to: (1) obtain a detailed characterization of PM in the Pittsburgh region; (2) obtain accurate current fingerprints of the major PM sources in and upwind of Pittsburgh region; (3) estimate the impact of power plants and other sources on ambient PM; and (4) quantify the responses of the PM characteristics to anticipated changes in coal plant emissions.

## Description

Three distinct activities are being performed in this project:

Ambient monitoring and characterization. An extensive database of ambient aerosol measurements has been obtained to assist in the project's source apportionment, model development, and model evaluation activities. This database will also establish the groundwork for subsequent research (independent of this project) on the human health effects of particulate matter. The focus of the measurement campaign is a "Supersite" located in an urban setting next to the CMU campus in Pittsburgh. The measurement campaign was conducted from May 2001 and through October 2002, consisting of regular (daily or more frequent) measurements of aerosol mass and composition, supplemented by two "intensive" measurement periods in July 2001 and January 2002. In addition, advanced technologies were deployed for near-real-time measurement of organic and elemental carbon, metals in particulate matter, detailed speciation of organic material, and the chemical composition of individual particles.

# Atmospheric Aerosol Source-Receptor Relationships: The Role of Coal-Fired Power Plants

Source Characterization. Existing emissions information on the sources of PM for the Pittsburgh region was reviewed, and activity data (i.e., quantities of emissions) for all known sources were compiled in preparation for modeling efforts. Detailed sampling using some of the same state-of the-art instrumentation as at the "Supersite" is being performed on major point sources in the Pittsburgh area such as coal-fired boilers, a coke plant, a steel mill, and an industrial manufacturing facility. Mobile source emissions are being characterized by conducting a tunnel study, and road dust samples are being collected and analyzed from various locations around western Pennsylvania. For sources such as steel mills and coke plants that do not have a single well-defined emissions point, fence line monitoring is being performed using highly time resolved instruments to develop an integrated fingerprint for the source.

Modeling. Using the single particle measurements and advanced "receptor modeling" techniques, the likely source of the particle nuclei and the secondary species contributions may be identifiable on a particle-by-particle basis. In addition, an updated version of a publicly-available chemical transport model (CTM) will be used to simulate atmospheric processes at multiple spatial scales. Given the updated emissions inputs and prevailing meteorology conditions, the CTM simulates the aerosol size-composition distribution for approximately 100 species (e.g., sulfate, nitrate, chloride, sodium, ammonium, elemental carbon, primary and secondary organic carbon, crustal elements, $H^+$, and water) throughout the model domain. After the model is verified by comparing its results with field measurements, it can be used to predict the changes in PM concentrations and composition resulting from various power plant emission scenarios, focusing on the changes that may occur in the upper Ohio River valley in response to current and future EPA regulatory requirements.

## Preliminary Results

The average daily concentration of $PM_{2.5}$ at the central Supersite was 17.4 µg/m$^3$ during the first six months of the measurement program. Average mass concentrations were 21.3 µg/m$^3$ during July - September and 12.6 µg/m$^3$ during October - December, 2001. The summertime composition at all monitoring sites was dominated by organic carbon and sulfate, while wintertime composition was dominated by organic carbon, sulfate, and nitrate. During all seasons, concentrations and composition of $PM_{2.5}$ at the Supersite were similar to those at the upwind and downwind sites, suggesting that regional sources (as opposed to local sources) were the dominant contributors. A noteworthy finding has been that up to 25% of the $PM_{2.5}$ mass consisted of particle-bound water on warm summer days, when the total $PM_{2.5}$ mass was the highest.

## Status

Ambient monitoring data will continue to be examined and interpreted for approximately one year. Source sampling activities are scheduled for completion by mid-2003. Modeling activities were initiated in the summer of 2002 and will continue for approximately 18 months. Numerous technical papers on the results of the work are currently being prepared for various scientific journals.

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## PROJECT PARTNERS

**University of Maryland**
College Park, MD
(real-time metals analysis)

**Clarkson University**
Potsdam, NY
(receptor modeling)

**RJ Lee Group, Inc.**
Pittsburgh, PA
(electron microscopy)

**Brigham Young University**
Provo, UT
(semi-volatile organics)

**University of Delaware**
Newark, DE
(single-particle analysis)

**University of California – Davis**
Davis, CA
(single-particle analysis)

**Rutgers University**
New Brunswick, NJ
(real-time organic/elemental carbon)

**Ohio University**
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(regional measurements)

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