

SPEAKER ABSTRACTS

OPENING PANEL

CLEAN ENERGY TECHNOLOGIES

Jim Lyons
GE Global Research

The development of renewable energy sources will be a significant economic driver in the twenty-first century. The market success of wind power can serve as a blueprint. The talk will address market drivers, government policies and incentives, and technologies driving the rapid evolution of wind power. Viable new clean energy technologies and sources will be assessed, including hydrogen.

ENVIRONMENTAL ISSUES RELATED TO THE ELECTRIC INDUSTRY

Ronald E. Wyzga
Electric Power Research Institute

Four areas are highlighted as key environmental issues for the electric industry: electromagnetic fields, the availability of water, global warming and climate, and air pollution. Greater electrification will require additional transmission facilities. This demand, coupled with past studies that have led to electromagnetic fields being classified a “possible carcinogen,” ensures that the issue will remain significant. Recent attention has been given to the hypothesis of “contact current” being a possible agent of concern. Further research on this topic is warranted. Electricity generation requires substantial amounts of water for cooling and other purposes. The demand for water is increasing in all regions of the United States. There is a need to reconsider our uses of water and see whether we can design “water sustainability” programs in an effort to conserve this valuable resource. There is increasing scientific agreement that anthropogenic activities are modifying the climate. There are many options for reducing emissions of greenhouse gases, but these have a wide range of costs, and the implications of alternative options for the electricity sector are huge. There is a clear need to understand the implications (costs and benefits) of alternative policy options, to help individual companies develop specific strategies to reduce CO₂ emissions, and to develop long-term technology strategies. Finally, despite improvements in air quality, air-pollution health and welfare concerns are not going away. Electricity-generating utilities will be reducing their emissions significantly in the next 10 years, but many of our urban areas will likely remain out of compliance with national standards even after these reductions. Further reductions, regardless of the sources targeted, will be very expensive; hence, there is a need to target those emissions that cause the greatest impact on health and welfare. More information is needed to inform these decisions. More detailed emissions inventories and detailed chemical characterization of particulate matter are needed to inform health studies and aid future air-quality management strategies.

ENVIRONMENTAL ISSUES RELATED TO THE NATURAL GAS INDUSTRY

Diane L. Saber
Gas Technology Institute

A recent survey conducted by the Gas Technology Institute (GTI) has determined that the word “environmental” possesses a wide variety of meanings within the natural gas industry. While traditionally associated with the cleanup of hazardous waste sites, “environmental” work now bridges into the divisions of operation and distribution, exploration, combustion technology, health and safety, and end use. The focus of environmental work can be grouped into specific areas of concern: greenhouse gases, PCBs, air quality, environmental cleanup support, pipeline integrity and pipe management, and produced waters from exploration.

The focus of traditional environmental work has changed significantly from 20 years ago. Cleanup of former manufactured gas plant sites has been approached with more sophisticated waste identification techniques, monitoring programs, and cleanup strategies. The increased use of forensic chemistry has contributed significantly to accurate source identification technology. New approaches have been developed, and research in this area has been continuing. Risk-based cleanup strategies for remediation are being verified through advanced analytical techniques and site testing.

In the area of gas distribution, pipeline integrity management has been dominant. The effects of environmental conditions that lead to pipeline deterioration and failure have been key components of research in this area. A substantial portion of pipe failure can be attributed to microbial growth in and around piping, and the effects of hydrocarbons on PE pipes is being studied in depth. Other operations-related issues include the development of methodologies for rapid identification of PCBs in or around pipes.

The most rapidly growing area of research concerns greenhouse-gas emissions and source identification techniques. Combined efforts have led to a variety of highly advanced methodologies for determining the source of methane in the environment. Protocol development for methane tracking and verification of source reduction has been bolstered by increased concern about global warming and climate change.

Other areas of research will be described, as well as programs that have worldwide interest, including substantial efforts in indoor air quality and the effects of LNG interchangeability on both indoor and outdoor air.

**SESSION A: AIR QUALITY AND RELATED HEALTH RESEARCH: PARTICULATES (PM) AND
CO-POLLUTANTS**

**WHAT IS IN AMBIENT PM_{2.5} IN NEW YORK?
WHERE ARE THESE COMPONENTS COMING FROM (LOCAL VERSUS TRANSPORTED)?**

Dirk Felton
NYS Department of Environmental Conservation

The New York State (NYS) Department of Environmental Conservation (DEC) began monitoring for PM_{2.5} using the Federal Reference Method in 1999. These data are used to determine compliance with air quality standards. The regional concentrations of PM_{2.5} demonstrate that PM_{2.5} is not strictly an urban problem. Instruments to measure PM_{2.5} are also available that provide hourly concentration data. Data from these instruments are used by DEC staff to produce forecasts of PM_{2.5} concentrations and to provide near-realtime data to the U.S. Environmental Protection Agency (EPA) AirNow website. The newest versions of these automated instruments, including some that measure specific species of PM_{2.5}, provide clues as to the limitations of the Federal Reference Method for PM_{2.5}.

**WHAT IS AMBIENT PM_{2.5} IN NEW YORK?
WHERE ARE THESE COMPONENTS COMING FROM (LOCAL VERSUS TRANSPORTED)?**

Kenneth L. Demerjian
SUNY Atmospheric Sciences Research Center

This presentation will focus on particulate matter (PM) composition and size distribution measurements in New York City based on results from the NYSERDA and U.S. Environmental Protection Agency PM_{2.5} Technology Assessment and Characterization Study (PMTACS-NY) "Supersite" program. Observed seasonal differences in PM composition and size distribution indicate that wintertime mean mode mass size distributions are significantly smaller on average than in summer, a phenomenon that is directly associated with photochemical gas-to-particle production. The percentage contribution of PM organics to total PM mass remains relatively constant throughout the year, but there is evidence for a substantial increase in the percentage contribution of secondary organics to total organics in summer. This is also the result of photochemical secondary organic production for volatile organic compound (VOC) precursor gases. The PM sulfate mass fraction is somewhat higher in summer than in winter, mainly owing to photochemical production in summertime (HO + SO₂) and heterogeneous reactions (SO_{2(aq)} + H₂O₂; O₃; et al.) in wintertime, although the latter processes are not well demonstrated in the field. The high PM_{nitrate} mass fraction observed in winter is driven by NH₄NO₃'s equilibrium temperature dependence. The details of the wintertime sources of the precursor gases (HNO₃ and NH₃) remain somewhat uncertain.

SOURCES OF FINE AIRBORNE PARTICULATE MATTER ACROSS NEW YORK STATE

Philip K. Hopke

Center for Air Resources Engineering and Science, Clarkson University

Over the past five years, a variety of data have been collected on the composition of fine airborne particulate matter across New York State. These data have been collected in a number of locations as part of the U.S. Environmental Protection Agency's Speciation Trends Network, while other data have come from NYSERDA's EMEP monitoring programs in Potsdam, Stockton, Tuxedo, and New York City. In addition, the New York City Supersite Project (PMTACS-NY) has produced highly time- and species-resolved data during intensives at Queens College in July 2001 and January 2004. Although not all of these data have been analyzed, much of the data has been analyzed using a variety of approaches. Multiple analyses have been done in the New York City area. The results of these various analyses will be summarized and compared with respect to the relative amounts of locally emitted and transported material. New York City results will be compared to results from rural and urban areas of northern and western New York.

EMISSION INVENTORIES AND AIR QUALITY MANAGEMENT

G. M. Hidy

Envair/Aerochem Associates

Emission inventories are a key element of effective air quality management practice. With increased demands of the stakeholders in air quality improvement, the requirements for detailed information about emissions from most sources have increased dramatically in recent years. As a major population and industrial center, New York State has been concerned about the quality of its inventories and their counterparts on a national scale. The New York State concerns are well reflected in a recent assessment of the state of science and technology underlying emission inventory developments (NARSTO 2005). Results of this assessment will be summarized with its recommendations in relation to New York State needs foreseen in the next decade. One of the important aspects of emission inventory improvement concerns the reduction in uncertainty of emission estimates through the application of new measurement methods. NYSERDA recently cooperated in a major dilution sampler development for $PM_{2.5}$ and an investigation of emissions from natural gas combustors. This study will be discussed as an important example of the kind of experiments that will be needed to establish self-consistent measurement standards and to improve mass emission data and source-composition profiles for stationary sources.

WHAT ARE THE LATEST FINDINGS REGARDING HEALTH EFFECTS FROM FINE PARTICULATE MATTER AND ASSOCIATED COMPONENTS ?

Maria Costantini
Health Effects Institute

A large number of epidemiological studies conducted in different locations have shown small, but statistically significant, associations between long-term and short-term exposure to particulate matter (PM) and increases in different measures of mortality and morbidity. Several studies found that the causes of death and the morbidity outcomes most strongly associated with elevated PM levels were cardiopulmonary diseases. Although consistent, these studies have raised questions about which groups of the population might be particularly susceptible, what are the possible mechanisms by which PM may cause effects, and whether certain particles or particle components are more toxic than others. This presentation will highlight results of recent epidemiological studies that have been aimed at addressing these questions. These include results of further analyses of the American Cancer Society study showing that death from cardiovascular causes had the strongest association with long-term exposure to PM_{2.5} and of a prospective study of children in Southern California showing an effect of long-term exposure to PM_{2.5} on lung growth. Some epidemiological studies of short-term exposure focusing on cardiovascular outcomes will also be presented, as this has been the emphasis of much recent research. A brief overview of possible mechanisms that may lead to cardiovascular and respiratory effects of PM will be discussed. Finally, a few studies aimed at understanding which components of PM may be more strongly associated with certain effects will be highlighted. The presentation will conclude with a brief discussion of remaining issues and research needs.

ENVIRONMENTAL PUBLIC HEALTH TRACKING: LINKING AIR QUALITY AND HEALTH EFFECTS DATA

Edward Fitzgerald
School of Public Health, University at Albany

The New York State (NYS) Department of Health (DOH) Center for Environmental Health has been funded by the Centers for Disease Control and Prevention (CDC) to develop an Environmental Public Health Tracking (EPHT) program. The primary goal of this program is to enhance the ability of state health and environmental agencies to conduct environmental health surveillance by linking health, hazard, and exposure data sets. A central component of the NYS DOH EPHT program is a pilot project focusing on air pollution, asthma, and cardiovascular disease in order to identify spatial and temporal patterns, clusters, and trends; respond to public health concerns; generate hypotheses; track health outcomes before and after the implementation of public health interventions; and identify data quality problems. The project includes an evaluation of different models for characterizing PM_{2.5} and ozone, as well as linkage of PM_{2.5} and ozone data with asthma and myocardial-infarction hospital admission data and myocardial-infarction mortality data. While these efforts will help enhance our understanding of associations between environmental hazards and health outcomes, they only serve as a basis for further research. The surveillance system cannot determine cause-and-effect relationships for several

reasons, including data quality issues (e.g., completeness and accuracy), lack of ability to control for confounders (e.g., smoking, socioeconomic factors, occupation), and lack of individual exposure data (e.g., residential history, mobility). Knowledge gained from current efforts will help advance the future vision of EPHT, including the possibility of a national network, as well as focused state tracking projects, improvements to the public health infrastructure, and an increased sharing of ideas and methods among state and federal researchers.

SESSION B: ECOSYSTEM RESPONSE TO DEPOSITION OF SULFUR AND NITROGEN

ACID RAIN MONITORING IN THE ADIRONDACKS AND CATSKILLS

Garry Boynton

NYS Department of Environmental Conservation

The New York State (NYS) Department of Environmental Conservation (DEC) has operated a network of acid deposition monitors in urban and rural areas across New York for the past 17 years. The Adirondack and Catskill state parks are particularly susceptible to the effects of acid deposition, and six of the 20 monitors are located in these two sensitive regions. This network complements the National Atmospheric Deposition Program (NADP) monitoring in New York. A comparison of sulfate, nitrate, and pH levels in wet deposition at Whiteface Mountain, where both the NADP and NYS DEC operate deposition monitors, shows consistent changes in these pollutants over the past decade and a half. Examination of the spatial distribution of changes in the concentrations of these pollutants indicates gradients across the state. Some of these changes may be attributed to the reduction in emissions of acid-rain precursors arising from the Title IV programs of the 1990 Clean Air Act Amendments, as well as state initiatives such as the State Acid Deposition Control Act (SADCA) and the Acid Deposition Reduction Program (ADRP). It is anticipated that the NYS DEC will continue this monitoring program to assess progress as new emissions reduction regulations are promulgated in the coming years.

INTEGRATED ASSESSMENT OF RECOVERY OF SURFACE WATERS FROM REDUCED LEVELS OF ACID DEPOSITION IN THE CATSKILLS AND ADIRONDACKS

Douglas Burns

U.S. Geological Survey

Gary Lovett

Institute of Ecosystem Studies

In light of recent reductions in sulfur (S) and nitrogen (N) emissions mandated by Title IV of the Clean Air Act Amendments of 1990, this project determined temporal trends and trend coherence in precipitation (1984–2001 and 1992–2001) and surface-water chemistry (1992–2001) in two of the most acid-sensitive regions of North America: the Catskill Mountains and the Adirondack Mountains of New York. Precipitation chemistry data from six sites located near these regions showed decreasing sulfate (SO_4^{2-}), nitrate (NO_3^-), and base cation (C_B) concentrations and increasing pH during 1984–2001, but few significant trends during 1992–2001. Data from five Catskill streams and 12 Adirondack lakes showed decreasing trends in SO_4^{2-} concentrations at all sites. Most sites show trends of decreasing NO_3^- , C_B , and H^+ concentrations and increasing dissolved organic carbon (DOC). By contrast, acid neutralizing capacity (ANC) increased significantly at only about one-half of the Adirondack lakes and one of the Catskill streams. Flow

correction prior to trend analysis did not change any trend directions and had little effect on SO_4^{2-} trends, but caused several significant trends in NO_3^- and ANC to become nonsignificant. This suggests that trend results for flow-sensitive constituents are affected by flow-related climate variation. Sulfate concentrations in precipitation, surface waters, and in precipitation–surface water comparisons showed high temporal coherence, reflecting a strong link between S emissions, precipitation SO_4^{2-} concentrations, and the processes that affect S cycling within these regions. Nitrate and H^+ concentrations and ANC generally showed weak coherence, especially in surface waters and in precipitation–surface water comparisons, indicating that variation in local-scale processes driven by factors such as climate are affecting trends in acid-base chemistry in these two regions.

**LONG-TERM MONITORING PROGRAM FOR EVALUATING CHANGES IN WATER QUALITY IN
ADIRONDACK LAKES 1982–2004**

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Charles Driscoll & Kimberley Driscoll
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James Dukett, Nathan Houck, Phil Snyder, & Sue Capone
Adirondack Lakes Survey Corporation

The Adirondack Long-Term Monitoring Program (ALTM) was established in 1982 to assess seasonal and long-term patterns in the chemistry of lakes in the Adirondack region of New York. The monthly sampling program, initiated with 17 lakes, was expanded in 1992 by an additional 35 lakes that were considered as being representative of lake classes across the Adirondacks. In this study, we report on time-series analyses on the acid-base status of ALTM lakes relative to changes in acidic deposition as a function of different sampling periods. Time-series analyses were performed for 16 nonlimed lakes covering the sampling periods of 1982–2000 and 1992–2000 (Driscoll et al. 2003) and 48 nonlimed lakes over 1992–2000 and 1992–2004 (Driscoll et al. 2005). Results indicate decreasing concentration trends in sulfates and increasing trends in pH and acid neutralizing capacity (ANC), which are not necessarily uniform over the monitoring periods. Lake nitrate changes have varied along with pH and ANC but are not explained by nitrate deposition changes. Dissolved organic carbon (DOC) increases have also been detected in a number of lakes. Low levels of pH and ANC with corresponding high levels of toxic inorganic monomeric aluminum (Al_{im}) continue to occur, particularly during springmelt. Year-round levels of Al_{im} remain high in several ALTM lakes. Preliminary results from lakes sampled more intensively during springmelt indicate that weekly sampling is more efficient at capturing spring depressions in pH and ANC.

Regional comparisons with other sensitive lakes and streams for 1990–2000 found that lakes in the Adirondacks responded similarly to those in New England and the Northern Appalachian Plateau with substantial declines in sulfate and base cations and small increases in pH, ANC, and DOC (Kahl et al. 2004).

ADIRONDACK STREAMS ASSESSMENT

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Assessments and monitoring have provided detailed information on the chemical condition of Adirondack lakes, a highly valued natural resource. In the absence of other ecological measurements, lake chemistry has also served as a general measure of acid deposition effects on this region, one of the most affected in North America. This focus on lake chemistry, however, has resulted in an incomplete picture of acid-rain effects. Because streams are unable to store neutralized water collected during baseflow periods and have little capacity to neutralize acidity through instream processes, they are more susceptible to acidification than lakes. Furthermore, stream chemistry is more useful as an index of ecosystem response than lake chemistry, because it better reflects terrestrial processes, in addition to representing a significant resource itself. Concentrations of inorganic aluminum (Al) in streams are particularly useful for evaluating acidic deposition effects, because (1) the occurrence of this form of Al in stream water indicates soil acidification and (2) once mobilized by acidic deposition, inorganic Al is harmful to biota in both aquatic and terrestrial ecosystems. Nevertheless, stream assessments are lacking, in large part, because early studies suggested that the episodic nature of stream acidification would make synoptic surveys highly uncertain if flows varied during collection.

To obtain current information on Adirondack streams, a synoptic survey was designed in the Oswegatchie and Black River drainages: 400,000 ha in the western Adirondack ecoregion. To reduce the effects of flow variation, the time required for collection was minimized by excluding streams not accessible within a one-hour hike from the nearest road. Streams were also excluded if upstream lakes or ponds affected more than 25% of the drainage area defined by the sampling site. Of the 565 streams that met these criteria, 200 were randomly selected for sampling. Samples were collected during high-flow periods on 27–29 October 2003, 29–31 March 2004, and 29–31 March 2005. Samples were also collected during low-flow periods, on 25–28 August

2003 and 16–18 August 2004. In conjunction with the stream chemistry analysis, periphytic diatom samples were also collected at all stream sites during the first four samplings to establish relationships between diatom community structure and water chemistry, and macroinvertebrate samples were collected at 40 sites during August 2004.

Preliminary data analysis indicates that in October 2003, inorganic Al concentrations equaled or exceeded 2.0 mol L^{-1} , the threshold for harmful effects on biota, in 54% of the streams. In March 2004, stream flows were lower than in the previous October, and 45% of the streams had inorganic Al concentrations $\geq 2.0 \text{ mol L}^{-1}$. In August 2004, 25% of the streams had inorganic Al concentrations $\geq 2.0 \text{ mol L}^{-1}$.

ASSESSMENT OF ADIRONDACK WATERSHEDS

Timothy B. Sullivan

E&S Environmental Chemistry, Inc.

Atmospheric deposition of sulfur and nitrogen over the past century has contributed to acidification of Adirondack lakewaters and likely depleted soil base-cation pools. It is hoped that lake and soil acid-base status will improve as acidic deposition declines in response to emissions controls enacted in association with the Clean Air Act Amendments of 1990 and other federal and state legislation. These changes in lakewater acid-base chemistry have been associated with changes in species composition of biological communities and reduction in the species richness of affected lakes. Biological effects of acidification have been observed at many taxonomic levels, perhaps most clearly for zooplankton.

As acidic deposition levels have declined over the past two decades, long-term monitoring programs have documented limited chemical improvement in some acidified lakes. It is unknown, however, to what extent the lakes included in the long-term monitoring programs represent the population of acid-sensitive lake watersheds within the Adirondack region, the degree to which biological recovery is occurring, or the extent to which chemical and/or biological recovery are expected in the future under existing or alternative emissions control regulations. This research effort addresses these questions using model simulations of past acidification and future recovery under three scenarios of future emissions control. The analysis is based on application of the MAGIC and PnET-BGC dynamic watershed models to 70 watersheds.

Results suggest that long-term monitoring lake watersheds are not regionally representative, but rather reflect conditions for the more acid-sensitive lakes within the region. Ongoing chemical recovery of lakewater is indicated by both measured and modeled data. However, model projections suggest continuing reduction in soil base saturation. As a consequence of continuing soil acidification, model projections that assume future emissions expected on the basis of existing regulations suggest future reacidification of many lakes that are currently recovering chemically. Expected biological responses are also being quantified. Model results suggest that this reacidification might be prevented under more stringent future emissions controls.

THE ADIRONDACK EFFECTS ASSESSMENT PROGRAM

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In 1994, the Adirondack Effects Assessment Program (AEAP) began a synoptic sampling program of physical and chemical parameters, bacterioplankton, phytoplankton, zooplankton, macrophytes, and fish on 30 ponded waters. The 30 waters are a subset of the waters included in the Adirondack Lakes Survey Corporation's Long-Term Monitoring (LTM) program of water chemistry (five additional lakes were added in 2002). In addition, the AEAP has been expanded to support both selected National Atmospheric Deposition Program (NADP) sites in New York State and event-based tributary sampling. Designed to assess the current state of different biological trophic levels as an estimate of ecosystem health, the AEAP has provided baseline data upon which to evaluate long-term (temporal) changes concerning future recovery of lake communities in this region. After 11 years of simultaneously evaluating the effects of acidification on multiple trophic levels in several types of lake systems, patterns can be correlated between various chemical and biotic variables. Quantitative data on biotic variables have provided insight into the interactive relationships between environmental factors and species abundance, biodiversity, and possible indicator species. A multi-institutional and multi-agency collaborative case study led by the Darrin Fresh Water Institute and the NYS Department of Environmental Conservation for one of the AEAP waters, Brooktrout Lake, including the restocking of brook trout scheduled for the fall of 2005, is also presented.

PANEL: SCIENCE AND POLICY ISSUES RELATED TO MERCURY IN THE ENVIRONMENT

MERCURY BASICS, CHEMISTRY, HEALTH EFFECTS, AND CONTROL TECHNOLOGIES

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Northeast States for Coordinated Air Use Management

Mercury is a known potent neurotoxin, particularly damaging to the development of the fetus, infant, and young child. A survey conducted by the Centers for Disease Control and Prevention and published in early 2003 found that one in 12 (8%) American women of childbearing age had mercury in their blood above the levels considered safe by the U.S. Environmental Protection Agency (EPA). This could result in as many as 4.7 million women of childbearing age with elevated levels of mercury and put approximately over three hundred thousand (322,000) newborns at risk for neurological deficits each year. More recent studies also suggest that mercury exposures can lead to adverse cardiovascular effects, including death in adults. Exposure to methylmercury, the most toxic form of mercury to which humans and wildlife are regularly exposed, comes primarily from the consumption of contaminated fish and shellfish. Current high levels of mercury contamination have led 45 states to issue advisories warning of the dangers of eating fish with elevated mercury concentrations.

Mercury is emitted both from anthropogenic sources (power plants, municipal waste combustion, steel mills, etc.) and natural sources (volcanoes). There are three forms of mercury: elemental, oxidized, and particulate. The atmospheric residence times of these three types of mercury are quite different, from days for oxidized and particulate mercury to a year or so for elemental mercury. What that means is that overall, mercury is a global, regional, and local pollutant, all at the same time, making it difficult to determine relative contributions of local, regional, and global sources at various receptor sites.

At the present time, coal-fired utility boilers are the largest single uncontrolled source category of mercury emissions, emitting about 48 tons per year or roughly 40% of U.S. emissions. The federal government has recently proposed a “cap-and-trade” approach to reduce these emissions by 20% by 2010 and by 70% in the 2018–25 timeframe. Many states in the Northeast (Massachusetts, New Jersey, and Connecticut) have passed regulations to reduce utility mercury emissions by much higher levels of 85%–95% and much sooner (by 2008–12). The technology to control mercury emissions by 90% and higher has been available for about a decade and has been widely and successfully applied to municipal waste combustors. The technology, Activated Carbon Injection, or other emerging and competing technologies are applicable to larger coal-fired boilers through technology transfer in a cost-effective manner.

MERCURY IN THE ATMOSPHERE

Thomas Holsen

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Clarkson University

This presentation will discuss the sources of mercury emissions to the atmosphere and the relative contributions of anthropogenic and natural emissions. Atmospheric mercury reaches the earth surface through the processes of wet deposition, dry deposition, and vapor exchange. Describing the three forms of mercury commonly found in the atmosphere (elemental, oxidized, and particulate), the talk will illustrate how the form of mercury influences its fate and transport. Relative concentrations of these three forms of mercury in New York State (NYS) will be presented. Techniques that can be used to link ambient measurements to potential sources will be described, and potential sources of mercury found in NYS discussed.

MERCURY MODELING

Russ Bullock

National Exposure Research Laboratory
U.S. Environmental Protection Agency

Current atmospheric mercury model development at the U.S. Environmental Protection Agency (EPA) will be described, along with some of the major scientific issues that continue to complicate matters. A description and status report on the North American Mercury Model Intercomparison Study (NAMMIS) will also be provided. The Community Multi-scale Air Quality (CMAQ) model continues to be updated to simulate atmospheric mercury based on scientific process information as it is published in the peer-reviewed scientific literature. The CMAQ mercury model was used by the U.S. EPA to support its recent Clean Air Mercury Rule (CAMR). The results obtained from the model to support the CAMR are strongly dependent on the validity of the gas-phase and aqueous-phase chemical kinetics information on mercury. A number of model sensitivity studies have been conducted to identify the areas of scientific research that still need more attention. The outcome of the NAMMIS involving the U.S. EPA, Environment Canada, Harvard University, and Atmospheric and Environmental Research, Inc. will also be very helpful in this regard.

**ATMOSPHERIC DEPOSITION, TRANSPORT, TRANSFORMATIONS, FATE, AND
BIOAVAILABILITY OF MERCURY IN FORESTED WATERSHEDS OF THE NORTHEASTERN
UNITED STATES**

Charles T. Driscoll

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Ronald Munson

Tetra Tech, Inc.

There is widespread mercury contamination in the Adirondack region of New York and elsewhere in the U.S. In remote forested regions like the Adirondacks, the source of mercury contamination is largely atmospheric deposition associated with atmospheric emissions. Forested regions are among the most sensitive areas for mercury inputs. Canopy trees filter mercury from the atmosphere, greatly enhancing deposition. Dry mercury deposition represents from 50% to 72% of total mercury deposition in the Adirondacks. Soils retain mercury inputs. However, shallow soils and associated shallow hydrologic flow paths allow for the transport of some mercury to surface waters. Wetlands that are prevalent in the Adirondacks are critical zones in the watershed landscape that supply dissolved organic carbon and facilitate the transport of inorganic mercury and methylmercury to downstream surface waters. Wetlands also provide reducing environments, which allow for the conversion of inorganic mercury to methylmercury in drainage waters. Methylmercury is the form of mercury that is highly toxic and bioconcentrates in the aquatic food chain. Unproductive lakes, like those in the Adirondacks, show particularly high fish bioconcentration of mercury. As a result of these characteristics, the western Adirondacks are a "hot spot" of mercury contamination. In the Adirondacks, methylmercury bioconcentrates from water to yellow perch by a factor of a million to 10 million. The bioaccumulation of methylmercury in yellow perch decreases with increasing concentrations of dissolved organic carbon (and wetland areas) as dissolved organic matter binds mercury, decreasing its bioavailability. In studies of yellow perch in the Adirondacks, 34% of the fish have concentrations of mercury above the 0.3 $\mu\text{g/g}$ action level suggested by the U.S. Environmental Protection Agency (EPA), and 96% of the lakes studied have at least one fish with mercury concentrations greater than 0.3 $\mu\text{g/g}$. Exposure of humans and wildlife to mercury largely occurs through consumption of fish. Humans and wildlife, such as loons, eagles, mergansers, mink, and otter, are at risk due to exposure to elevated concentrations of methylmercury. Although most studies of mercury to date have focused on the aquatic food chain, there is some evidence that mercury can also bioconcentrate through the terrestrial food chain and impact songbirds. The Mercury Cycling Model for Headwater Drainage lakes (MCM-HD) has been developed to synthesize studies of mercury dynamics in forest watersheds. Simulations have been conducted to illustrate the response of an Adirondack lake-watershed (Sunday Lake) to hypothetical decreases in atmospheric mercury deposition.

MERCURY IN THE COASTAL ENVIRONMENT

William F. Fitzgerald

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Consumption of marine fish and seafood products is the principal pathway by which humans are exposed to the toxic organo-mercurial methylmercury (MeHg). Thus, biologically productive nutrient-rich near-shore regions, which support major commercial and recreational fisheries, are of special interest. Mercury research in the oceans is limited. Nevertheless, it is apparent that biologically mediated sedimentary production of MeHg in the coastal zone is significant, with the potential to affect its bioaccumulation not only locally, but also regionally, and thereby to impact pelagic fisheries. The cycling of Hg and MeHg in coastal ecosystems will be explored using recent experimental data from New York Harbor, Long Island Sound, and the continental shelf off southern New England. Connections between the production of MeHg in coastal sediments and direct and indirect (watershed runoff and riverine fluxes) atmospheric Hg loadings, which contain anthropogenic components, will be made evident.

LONG-TERM MONITORING AND ASSESSMENT OF MERCURY BASED ON INTEGRATED SAMPLING EFFORTS USING THE COMMON LOON, PREY FISH, WATER, AND SEDIMENT

Nina Schoch

Adirondack Cooperative Loon Program
Wildlife Conservation Society

David Evers & Melissa Duron

BioDiversity Research Institute

Michale Glennon

Wildlife Conservation Society

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Bureau of Habitat, NYS Department of Environmental Conservation

Charles Driscoll

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The Adirondack Cooperative Loon Program, a partnership of the Wildlife Conservation Society, Natural History Museum of the Adirondacks, New York State (NYS) Department of Environmental Conservation, BioDiversity Research Institute, and the Audubon Society of New York, is using the common loon (*Gavia immer*) as an indicator species to assess the mercury exposure and risk in aquatic ecosystems in New York's Adirondack Park. As part of a long-term study examining loon survival and reproductive success in relation to mercury, abiotic (water and

sediment) and biotic (loon, prey fish, crayfish, and zooplankton) samples were collected from 44 lakes in the Park from 2003 to 2004. Mercury analysis of these samples is used to develop a mercury exposure profile to evaluate the ecological risk that mercury deposition poses to Adirondack waterbodies. Ecological risk will be quantitatively assessed using a formula for a wildlife criterion value to determine if the water column mercury value is protective of wildlife at the population level in the Adirondack Park. Differences in reproductive success and survival in common loons in relation to their mercury exposure are used to develop a mercury hazard profile. A population model will also be developed to determine if mercury contamination is affecting the population growth rate of loons in the Adirondacks. Results of this project will enable researchers, regulatory agencies, and policymakers in New York State to make informed decisions regarding regulation of airborne pollutants and management of wildlife species and freshwater ecosystems.

MERCURY IN NEW YORK STATE FISH

Howard Simonin

Bureau of Habitat

NYS Department of Environmental Conservation

New York State began monitoring mercury concentrations in fish in 1969. In the decade that followed, mercury concentrations decreased in some New York State waters as a result of water pollution controls. In recent years, the primary focus has been on atmospheric sources of mercury and high mercury concentrations in fish in waters remote from industrial sources. Methylmercury bioaccumulates up the aquatic and terrestrial food chains more than almost any other chemical. Concentrations in top predator fish can be over a million times the concentration of methylmercury in the water. Variables that affect this bioaccumulation include not only the amount of mercury available, but also the fish species, size and age of the fish, length of the food chain, and several lake variables, including pH, color, amount of wetlands, and lake productivity. Walleye, largemouth bass, smallmouth bass, northern pike, and large yellow perch have frequently been found with high mercury concentrations, while lower-trophic-level species such as brown trout, brook trout, sunfish, and bullhead are most often low in mercury. Our hope is that a better understanding of mercury concentrations in the environment will lead to policy decisions that reduce mercury levels to the extent that fish and fish-eating wildlife are no longer impacted, and human fish consumption advisories for this toxic chemical are dropped.

REDUCING EMISSIONS FROM THE ELECTRICITY SECTOR: THE COSTS AND BENEFITS NATIONWIDE AND IN THE EMPIRE STATE

Karen Palmer, Dallas Burtraw, & Jih-Shyang Shih

Resources for the Future

Recent federal policy proposals to reduce emissions of SO₂, NO_x, and mercury from the U.S. electricity sector promise important improvements in air quality and reductions in acid deposition in New York State and across the nation. The cost of achieving these reductions depends on the

form and stringency of the regulation. In this research, we analyze the economic benefits and costs of the U.S. Environmental Protection Agency's Clean Air Interstate Rule (CAIR) as characterized in the supplemental rule proposed in June 2004 and the Clean Air Mercury Rule (CAMR) as proposed in February 2004. The assessment integrates a model of the electricity sector, two models of atmospheric transport of air pollutants, and a model of environmental and public health endpoints affected by pollution. We model explicitly the emissions of SO₂, NO_x, mercury, and CO₂ and the effects of changes in emissions of SO₂ and NO_x on environmental and public health. The manner in which mercury emissions are regulated will have important implications not only for the cost of the regulation, but also for emission levels for SO₂ and NO_x and for where those emissions are located. We find the economic benefits of CAIR and CAMR are far greater than the costs. Recent estimates of benefits of reductions in mercury and acidification indicate that our model captures the lion's share of quantifiable benefits. With tighter mercury targets (beyond the U.S. EPA's CAMR), a maximum achievable control technology (MACT) approach would preserve the role of coal in electricity generation.

PANEL: SCIENCE AND POLICY ISSUES RELATED TO CLIMATE CHANGE

CLIMATE CHANGE RESEARCH IN NORTHEASTERN FOREST ECOSYSTEMS

Lindsey Rustad

U.S. Department of Agriculture Forest Service

An overwhelming scientific consensus exists that twentieth-century human activities have induced dramatic and unprecedented changes in the earth's atmospheric chemical and physical environment (IPCC 2001). In New England, the historic record (1895–1999) indicates that the regional climate has warmed by an average of $\sim 0.4^{\circ}\text{C}$ over the last century and that precipitation has increased by an average of $\sim 4\%$, with both showing considerable temporal and spatial heterogeneity within the region (NERA 2001). Projections for the future suggest that temperature will continue to increase by 3.1° – 5.3°C in the next century and that precipitation will increase by 10%–30%, with a greater frequency and severity of droughts and greater intra- and interannual climate variability (NERA 2001). Because temperature and moisture affect virtually all biological, chemical, and physical processes, these seemingly subtle climatic changes will have profound impacts on northern forest ecosystems.

The northeastern United States and eastern Canada have a rich history of long-term monitoring and ecosystem-scale research at world-class field sites such as the Hubbard Brook and Bartlett Experimental Forests in New Hampshire, the Harvard Forest in Massachusetts, the Huntington Forest in New York, and the Bear Brook Watershed in Maine. The data from these and other sites provide numerous indices of climatic change, including temperature and precipitation records, trends for earlier spring ice-out dates, thinner lake ice depths, changes in hydrological flow patterns, changes in plant phenology, and changes in the abundance of small mammals, birds, and the insects they feed on. All indices support a trend toward a warmer regional climate.

The northeastern United States and eastern Canada also support a broad range of research targeted specifically at climate change. Four ecosystem warming experiments, for example, have been conducted over the past 20 years within the region and provide evidence for changes in key ecosystem processes, such as soil respiration, N mineralization, and litter decomposition in response to warming. Precipitation manipulation experiments, particularly those simulating winter or summertime drought, have also demonstrated significant effects, especially on the N cycle. Similar changes in biogeochemical properties in relation to temperature and moisture have been observed in elevational and latitudinal gradient studies, or space-for-time substitutions. Models provide additional tools for investigating forest ecosystem response to changes in climate. The PnET model, for example, has been used to simulate changes in the magnitude and timing of droughts, and results suggest that spring droughts may have more of an effect on plant productivity and N cycling than late summer or fall droughts.

Taken together, these studies suggest that changes in temperature and moisture, in the ranges predicted for the near- to mid-term future (i.e., 20–100 years) will have significant consequences for the structure and function of northern forest ecosystems.

INDEPENDENT AND JOINT IMPACTS OF HEAT AND OZONE ON MORTALITY RISK UNDER A CHANGING CLIMATE

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Climate change is likely to result in both increased heat and ozone (O₃) levels in urban areas over the coming century. To assess potential human health impacts of these changes, models are needed for projecting regional-scale temperature and O₃ in response to climate change and for characterizing the independent and joint health effects of heat and O₃. To meet these needs, exposure-response relationships for summer heat and O₃ were developed and applied in a regional health risk assessment for the New York City metropolitan region. The objective was to analyze and project the relative impacts of climate-related changes in heat stress or ground-level O₃ concentrations on acute nonaccidental mortality from all internal causes of death. Exposure-response relationships were developed using a 10 year record of daily observations for the region (1990–1999). This was done using a time-series Poisson regression model that jointly estimated O₃ and temperature effects on mortality, controlling for time trends and day-of-week effects. To project impacts into future decades, we developed an integrated modeling system that took global-scale climate projections for the 2020s, 2050s, and 2080s, and downscaled these to a 36 km grid using regional models for climate and air quality. Regional downscaling was carried out using the MM5 model for climate and the Community Multiscale Air Quality (CMAQ) model for air quality. Mortality risks were estimated using the exposure-response relationships, estimated using the 1990s data. Sensitivity analyses were carried out using published exposure-response coefficients from other locations and time periods. Results showed that both O₃ and heat stress had measurable impacts on mortality risk, but that the relative impacts changed over time. This modeling strategy could be applied in other metropolitan areas and for other health outcomes to assess health impacts of heat and O₃ under a changing climate.

NEW YORK CITY REGIONAL HEAT ISLAND INITIATIVE

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New York City, like other large cities, is warmer than surrounding areas because of the urban heat island effect caused by absorption of heat by building materials and lack of vegetation. Heat island mitigation strategies, such as urban forestry, living/green roofs, and light surfaces, could be implemented at the community level within New York City. This study evaluates whether these strategies can reduce surface and near-surface air temperatures enough to have a measurable impact on energy demand, especially at peak times on hot summer days. The objectives were to analyze and model the summer heat island effect in New York City and test potential mitigation strategies. Methods included analysis of observed meteorological data; Landsat, ASTER and MODIS satellite data; and environmental characteristics, including albedo, normalized difference vegetation index (NDVI), building height, and road network density. The MM5 mesoscale model and an energy-balance model were used to characterize surface and near-surface temperatures associated with impervious surfaces, grass, and trees in six case-study areas and for New York City as a whole. Mitigation scenarios tested included open-space planting, curbside planting, living roofs, and light surfaces separately and in combination and at different intensities of adoption. Three heat waves during the summer of 2002 were used to test the mitigation scenarios. Results show that curbside planting is an individual strategy with effective cooling potential. In areas with greater available space for rooftop redevelopment, living roofs are also effective. Owing to the large areas of impervious surfaces, light surfaces also have potential cooling effects.

NEW YORK STATE INITIATIVES TO REDUCE GREENHOUSE GASES

Karl Michael
NYSERDA

The presentation will focus on the Regional Greenhouse Gas Initiative (RGGI), a cooperative effort of nine northeastern and Mid-Atlantic states, initiated by Governor Pataki, to develop a model rule for a regional carbon cap-and-trade program in the electricity sector. Discussion will include the key elements of the RGGI proposal under consideration, the ongoing public process to develop the proposal, and highlights of the energy modeling work to estimate the potential impacts on wholesale electricity prices, carbon emissions, generation capacity, fuel diversity, and imports of electricity.

**PLENARY DISCUSSION: ENERGY-RELATED ENVIRONMENTAL RESEARCH –
SETTING PRIORITIES IN A CHANGING POLICY LANDSCAPE**

Carl Johnson

NYS Department of Environmental Conservation

The NYS Department of Environmental Conservation will discuss the interrelationship of research needs, environmental trends, and policy direction. Clean air policy follows a long process involving public health and environmental research that leads to the setting of air-quality goals, necessitating an understanding of available options for meeting those goals. Ever-evolving understanding of both the health and environmental science drives an iterative process, advancing policy options toward ultimate air-quality goals.

Robert Teetz

Environmental Licensing and Compliance, KeySpan

My remarks will concentrate on some of the cost and system-reliability implications that result from the implementation of environmental policy. I hope to demonstrate that there is greater need for research to be conducted and that such research be used to more thoroughly inform and educate policymakers, the media, students, and the public of the costs and benefits of regulatory initiatives prior to advocating policy initiatives that are often politically rather than scientifically motivated.