III. Summary of Findings from EMEP-Supported Projects Crosscutting the Topics of Air Quality, Health, Ecological Response, and Energy

Preface

This summary, which focuses on "crosscutting" research projects was prepared by NYSERDA staff to assist with program evaluation efforts and facilitate discussions at the upcoming evaluation and planning meeting with EMEP Program Advisors and Science Advisors. Conclusions drawn from this effort will assist in determining research needs related to the EMEP program and help focus future research solicitations.

Introduction

Research supported under this EMEP focus area cuts across a range of energy-related environmental issues. Projects included in this focus area may address pollutants associated with both fine particle pollution and acid rain impacts. Often these are multimedia studies or multi-pollutant studies. Several of these projects include an economic, technology, or policy analysis component.

1. Costs and Benefits of Reducing Emissions from the Electricity Sector

In 2004 an assessment was conducted of several proposed regional and national emission control strategies to reduce SO2, NOx, and mercury including: (i) the Clean Air Interstate Rule (CAIR) combined with a mercury cap; (ii) CAIR combined with a mercury cap and seasonal SIP NOx policy; (iii) CAIR plus a tighter mercury control using Maximum Achievable Control Technology (MACT); and (iv) CAIR plus a tighter mercury standard with trading.

A suite of models, including a model of capacity planning and operation for the U.S. electricity sector, an integrated assessment model of air transport and environmental effects, and a state-of-the-art air chemistry model for the eastern United States was used for a broad assessment of the costs and benefits of these proposed policies. In evaluating the potential environmental benefits of these proposals, researchers specifically analyzed how they would influence emissions from power plants that affect air quality in New York State and the nation.

This project resulted in several important findings, which are presented below.

- Benefits to the nation and to New York State significantly outweigh the costs associated with reductions in SO_2, NOx, and mercury, and all policies show dramatic net benefits.

- 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 and emission locations for SO_2 and NOx.

- Contrary to EPA=s findings, CAIR as originally proposed by itself would not keep summer emissions of NOx from electricity generators in the SIP region below the current SIP seasonal NOx cap. In the final CAIR, EPA added a seasonal NOx cap to address seasonal ozone problems. CAIR with the seasonal NOx cap produces higher net benefits.

- The effect of the different policies on the mix of fuels used to supply electricity is fairly modest under scenarios similar to the EPA=s final rules.

- A maximum achievable control technology (MACT) approach, compared to a trading approach as the way to achieve tighter mercury targets (beyond EPA=s proposal), would preserve the role of coal in electricity generation.

- The evaluation of scenarios with tighter mercury emission controls shows that the net benefits of a maximum achievable control technology (MACT) approach exceed the net benefits of a cap and trade approach.

Supporting EMEP Project:
Multi-Pollutants Policies for the Electricity Sector and Environmental Quality in the Empire State, Palmer et al., No. 7610.

2. New York City Regional Heat Island Mitigation

New York City, like other large cities, is warmer than surrounding areas due to the urban heat island effect, which occurs when impervious built surfaces such as roads and buildings absorb solar radiation and re-radiate it in the form of heat. The development of a heat island has regional-scale impacts on energy demand, air quality, and public health. Heat island mitigation strategies, such as urban forestry, living (green) roofs, and light-colored surfaces, could be implemented at the community level within New York City, but their effects need to be tested with comparable methodologies. Although the heat island effect occurs throughout the year, its occurrence during the summer months is of particular public policy concern because of the association of higher temperatures with increases in electric demand due to air conditioning, elevated air pollution, and heat-stress-related mortality and illness.

This study used a regional climate model (MM5) in combination with observed meteorological, satellite, and GIS data to determine the impact of urban forestry, living roofs, and light surfaces on near-surface air temperature in New York City. Nine mitigation scenarios were evaluated city-wide and in six case-study areas. Temperature impacts were calculated on a per-unit-area basis, taking into account the available land area for implementation and other physical constraints. The scenarios were then evaluated based on their cost-effectiveness at reducing air temperature and consequent lower demand for electrical energy for air conditioning.

Results show that significant reductions in New York City=s near-surface air temperature, generally defined as the air temperature 2 meters (6 feet) above the street or surface level, can be achieved by implementing heat island mitigation strategies. Effects vary in magnitude across scenarios, case-study areas, and heat-wave days. The city-wide simulated temperature impact of the mitigation scenarios ranged from 0.11F (<0.11C) for open space planting to 0.71F (0.41C) for

ecological infrastructure (a combined strategy of urban forestry and living roofs), if 100% of the available area is redeveloped, averaged over all heat-wave days and times.

Model results also indicate that the most effective mitigation strategy per unit area redeveloped is curbside planting. The average difference in simulated near-surface air temperature between impervious surfaces and trees was 3.51F (1.91C), which was higher than the differences between other surface-cover types. Therefore, street trees—which involve redevelopment of impervious surfaces—have the largest cooling potential per unit area, followed by living roofs, light-colored surfaces, and open-space planting.

A combined strategy that maximizes the amount of vegetation in New York City by planting trees along streets and in open spaces, as well as by building living roofs, offers more potential cooling than any individual strategy. The choice of a strategy should consider the characteristics and priorities of the neighborhood, including benefit/cost factors and the available area for implementation of each strategy.

Supporting EMEP Project:
New York City Regional Heat Island Mitigation, Rosenzweig et al., No. 6681

3. Combined Heat & Power (CHP) and Distributed Generation

3.1 Emission Reduction Credits and Emission Allowance Market Opportunities for Small CHP Projects in New York State

Combined heat and power (CHP), which involves the coincident production of heat and electrical/mechanical power from a single process and fuel source, may be a suitable option in industrial, institutional, commercial, municipal, and residential applications. CHP can be cleaner and more efficient and reliable than conventional methods of separately generating heat and power, as heat that is normally wasted in generating central-station electricity is instead used near the CHP system. By taking advantage of this otherwise wasted heat, CHP significantly increases overall energy efficiency. In addition, because CHP is located at the end-user's site, there are virtually no transmission and distribution line losses, which typically diminish the amount of power delivered from central power plants to the consumer by 5%-10%.

This policy study developed a guidebook for determining how an end user installing CHP can quantify and secure emissions reduction credits (ERCs) from the New York State Department of Environmental Conservation (NYSDEC). It also performed an evaluation of how existing NYSDEC allowance-based regulations can be interpreted and implemented to transform the general intent of program rules into a practical and effective mechanism to incentivize CHP projects. By receiving ERCs or set-aside allowances, CHP projects can obtain financial benefits that could help promote the installation of additional CHP systems, benefiting the environmental and economic health of New York State.

3.2 Quantifying the Environmental and Economic Benefits of Increased Deployment of Combined Heat and Power (CHP) Technologies

The goal of the ongoing project is to increase understanding of the positive and negative impacts of increased deployment of DG/CHP technologies throughout New York State. Increased deployment of DG/CHP systems in New York State can reduce emissions of greenhouse gases (CO_2) and criteria air pollutants (NOx, SOx, Hg, VOC, PM, and CO). Greenhouse gas emission reductions result from the fact that a DG/CHP system can satisfy overall on-site energy demand (electric and thermal) more efficiently than conventional alternatives (i.e., purchasing electricity and natural gas separately from the local utility). Less fuel is needed to satisfy the same demand, resulting in lower overall carbon dioxide emissions. Criteria air pollutants can be reduced when multiple DG/CHP systems collectively produce enough electric energy to partially/fully displace the operation of a "dirty" peaking plant. The price of electric energy in New York State's de-regulated market is determined by the operating cost of the power plant providing the marginal generation needed to satisfy peak demand. These marginal generating facilities are typically the least efficient and most expensive to operate, resulting in high wholesale market clearing prices. A collection of DG/CHP systems, with an aggregated power output equal to or greater than that of an expensive large-scale peaking plant, may reduce the amount of time throughout the year that these higher-cost units will need to operate. This project is using a variety of modeling tools to explore and quantify these potential impacts.

Supporting EMEP Projects:
Analysis of New Pollution Control Strategy Utilizing Emission Reduction Credits and Small-Scale Combined Heat and Power Units, No. 7615.

Quantifying the Environmental Benefits of Increased Deployment of Combined Heat and Power Technologies in New York State, No. 7617.

4. Measurement of Ambient Gaseous Ammonia

Gaseous ammonia is of increasing interest as an atmospheric gas due to its role in forming aerosol particles such as ammonium nitrate and ammonium sulfate. Ammonia is not measured routinely in any of the major sampling networks. The State University at Albany's Atmospheric Science Research Center is performing an evaluation of six different gas-phase ammonia analyzers to determine if any are suitable for routine deployment. The first step was a laboratory intercomparison of instruments including two commercial continuous low-level ammonia analyzers, one based on chemiluminescence and the other on ion mobility spectrometry along with three research-grade ammonia instruments and a third commercial analyzer on lone from another institution. Following the laboratory intercomparison, the ion mobility spectrometer was deployed for three months at Pinnacle State Park in order to obtain ambient-air ammonia measurements.

The preliminary findings indicate that measurement of gaseous ammonia continues to be a challenge. It is extremely sensitive to materials used in sample lines and the analyzer itself. With unlimited resources, the tunable diode laser has the fastest response, good sensitivity, and good accuracy. With respect to routine monitoring, the ion mobility spectrometer appears to have

sufficient accuracy, sensitivity and robustness to provide reliable field measurements. However, time response and absolute accuracy continue to be areas where more work is needed.

Supporting EMEP Projects:
Ambient Gaseous Ammonia: Evaluation of Continuous Measurement Methods Suitable for Routine Deployment. Schwab, No. 8642.

5. Novel Approach for Determining Sources of Atmospheric Nitrogen

Increasing inputs of reactive nitrogen (N) to ecosystems in the northeastern USA have been linked to many environmental concerns, including acidification of ecosystems, accumulation of N in groundwater, and eutrophication of waterways. The role of atmospheric N deposition is of particular interest to land managers and policy makers, as rates of atmospheric N deposition in the northeast are among the highest in the nation. The sources of atmospheric N deposition include industrial, automotive, and agricultural emissions, and data regarding the relative contributions of these sources are needed in order to develop sound strategies for managing and understanding the effects of these and other N inputs to the landscape.

This project uses novel isotopic tracer techniques to assess the importance of atmospheric nitrogen deposition in New York State. New methods are being refined to measure isotopes in the nitrate (NO_3^-) molecule including oxygen-17 ($\Delta^{17}O$), oxygen-18 ($\delta^{18}O$), and nitrogen-15 ($\delta^{15}N$). the project is exploring the feasibility of using this trio of isotope tracers to quantify: (1) the relative contributions of different sources of atmospheric N to precipitation (e.g., distinguishing between stationary, automotive, and agricultural sources), and (2) the relative contributions of different sources of atmospheric nitrate to several New York watersheds.

Isotopic compositions of the following are being analyzed: (1) wet and dry deposition samples collected within New York's airshed, (2) dry deposition samples collected from various emissions sources, (3) surface water samples from streams and rivers in a variety of environmental settings in New York watersheds, and (4) wet deposition from a national-scale network of sites.

Preliminary results show the following:

- $\delta^{15}N$ is spatially variable. A well-documented N deposition gradient exists across the Mid-western and Northeast U.S. $\delta^{15}N$ values are highest in the west and decrease eastward. This spatial gradient persists throughout the year.
- $\delta^{15}N$ is correlated with indicators of atmospheric deposition. $\delta^{15}N$ values are significantly correlated with nitrate concentration, sulfate concentration, and pH from precipitation collected at each of the NADP sites throughout the year. These results suggest that the spatial variability of $\delta^{15}N$ over the Northeastern region is source-related. In particular, the correlation between $\delta^{15}N$ and sulfate deposition suggests that the NO_x affecting $\delta^{15}N$ values is likely derived from stationary rather than mobile source emissions.
- Spatial and temporal analyses with electric generating unit emissions by county showed the strongest correlations between $\delta^{15}N$ and NO_x emissions within 300-400 mile radial areas of NADP sites, suggesting the source area for atmospheric deposition to this region is approximately 300-400 miles away.

- $\delta^{15}N$ values are lower in the summer than the winter. The seasonality is consistent across all sites.

The results of this national study are unprecedented in characterizing the spatial variability associated with the isotopic composition of precipitation nitrate. It is anticipated that isotopic tools will be a valuable asset for deciphering sources of atmospheric deposition in New York landscapes, as well as the fate of atmospheric N among multiple N sources in New York watersheds.

Supporting EMEP Project:
Quantifying Atmospheric Nitrogen Sources with New Stable Isotope Techniques, Kendall et al., No. 7609/8183