# B. Air Quality and Health Effects

This EMEP program area will support research to improve the scientific and technical foundation for the following key policy-relevant questions:

- What are the weaknesses in the energy-related emissions estimates for New York, which, if addressed, would improve the assessment of emissions and exposure reduction strategies for air pollutants?
- Energy systems and use change over time. What are the significant changes that are occurring in the power, building heating and cooling, and transportations sectors and what are the anticipated changes (increases and decreases) in emissions and exposure estimates?
- What is the optimal mix of local and regional emission-control measures for PM2.5 constituents that will represent a cost-effective means of achieving the annual and daily PM2.5 standards in New York? How might sub-daily patterns or human exposure change?
- What are the links between energy sources, ambient concentrations, and exposures for energy-related emissions in New York environments?
- Are there mitigation options that can help reduce the specific components of the combustion-related fine particle/oxidant complex that are causing adverse health effects? What are the impacts of these alternative mitigation options on emissions of climate-forcing agents?
- What are the local and regional implications for energy production and use from potential composition-specific, size, or sub-daily, PM2.5-standard proposals in the next decade?
- What are the local and regional implications for energy production and use from a decrease National Ambient Air Quality Standards in the next decade?
- What are the local and regional implications to National Ambient Air Quality Standards in the next decade due to changes in conventional and renewable energy markets (i.e natural gas, biomass). How might sub-daily patterns or human exposure change?
- Are energy regulations and policies having the intended outcome for reduced emissions, ambient concentrations, and exposure reductions of air pollutants?
- Are there changes in the roles of certain atmospheric chemical reaction mechanisms that have resulted due to changes in emissions?

## B.1. Air Quality Trends, Including Monitoring and Modeling

In order to address the above questions, it is necessary to characterize ambient PM2.5 and precursor gases due to combustion processes. There is great interest in organic species due to their large contribution to PM2.5 mass and a need for greater understanding of semivolatile species and the atmospheric processes controlling them. Due to the importance of organic species, Topic B.1.a focuses entirely on improving the monitoring, characterization, and understanding of atmospheric processing of organic PM2.5 and precursor species. However, there is still a need to characterize other trace species resulting from combustion processes (Topic B.1.b).

Improved modeling tools for trends analysis as well as accountability studies (Topic B.1.c) will be necessary to determine whether emission-control measures are having a positive impact on air quality.

This section of the research plan will also focus on opportunities integrating air quality observation systems with chemical transport models for improved air quality forecasting (Topic B.1.d) and for multi-pollutant air quality management strategies (Topic B.1.e).

### *Topic B.1.a: Combustion Products—Improve Monitoring, Characterization, and Understanding of Processes Involving Organic Species*

**Problem Statement**

Energy production and use involves multiple fuels that, when combusted, emit gaseous and particulate carbon compounds (organic carbon [OC] and elemental carbon [EC]). These carbonaceous species affect the formation of secondary aerosol particles and ozone. The chemistry and nature of these compounds are the least well characterized of all air pollutants, yet carbon comprises more than 40 percent of the PM2.5 mass in New York City on an annual basis. Understanding the sources and processes by which carbon compounds form PM2.5 is critical for developing effective control strategies.

Advancing our knowledge about the carbon in air pollution depends on combined measurements of speciated volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and secondary organic aerosols (SOAs). Only with combined measurements can a complete description of the organic fraction in air be determined.

**Research Focus**

PM: Improved spatial and temporal measurements of speciated organic aerosols are needed to assist in identifying the sources and concentration gradients of organic aerosols in New York State. Source apportionment using additional tracers to identify major source types, regions, or events (ex. wildfires) will also be useful. In addition, highly time-resolved data of organic PM species may assist in identifying diurnal patterns of secondary aerosol production and the processes involved. The interpretation of this ambient data will need to be supplemented with ambient VOC measurements and emissions inventory data (Topic B.2).

Measurements of PM2.5 and OC in rural regions show that biomass combustion for heat and power is the major contributor to wintertime rural PM. In Rochester, NY PM from wood combustion has been observed to contribute 30% of PM2.5 mass during winter. Topography and meteorology greatly impact ambient wood smoke concentrations and exposure. There is a need to characterize emissions and ambient concentrations due to wood combustion and trends over time as new technologies are phased in and old inefficient ones are retired.

Technologies for vehicles are also changing and more electric and hybrid-electric vehicles are entering the fleet. Vehicle ownership is trending downward and more complete street planning allows for alternative transportation. These changes in emissions, localized and regional ambient air quality and exposure also need to be characterized.

VOCs: Improved information is needed with respect to VOC sources, role in aerosol formation, role in ozone formation, control technology options, and data gaps. In addition, highly time-resolved measurements of speciated ambient VOCs are needed for both anthropogenic and biogenic species, to estimate the significance of their impact on photochemical oxidant cycles leading to ozone and secondary organic aerosol, regionally and locally. This may also require measuring other oxidant species. Data interpretation needs to consider not only the spatial and temporal (especially seasonal) distributions of VOCs and secondary organic aerosols, but also the potential for end-product formation during atmospheric processing (e.g., formaldehyde, acetaldehyde, acrolein, organic nitrates). In addition air toxics also need to be characterized.

### *Topic B.1.b: Atmospheric Species—Improve Monitoring, Characterization, and Understanding of Processes*

**Problem Statement**

The production and use of energy results in emissions of many gaseous and solid chemical species. These emissions may be involved in numerous complicated atmospheric processes, including ozone production or aerosol formation. In addition to Topic B.1.1, which focused on organic species, much information is needed to characterize atmospheric species, including trace gas concentrations, particle size distributions, and chemical composition of aerosols. The species of interest in the atmosphere include not only those species that are directly emitted or that are formed through atmospheric chemistry, but also intermediate species that can provide insights into the chemistry. Beyond ground-based measurements, the vertical profile and synoptic-scale spatial distributions of aerosols and gases are needed for improved understanding of atmospheric processing and air quality management. (Note: Mercury measurements are addressed in Topic A.1.)

**Research Focus**

- Perform highly time-resolved measurements of NOy, NOx, $HNO_3$, HONO, PAN, H2O2, CO, $O_3$ $NH_3$ organic peroxides, and VOCs in urban and regional atmospheres in New York State to improve the quantitative understanding of atmospheric oxidation cycle and ozone production.
- Review and analyze for quality and speciation the PAMS network data and other data (e.g. supersite and satellite locations-e.g., Pinnacle and Whiteface; IMPROVE sites, other) for New York to construct a history of NMOC speciated data for comparative regional and urban trend analysis.
- Review and interpret existing oxidant measurements in selected urban and rural sites and combine with photochemical modeling to look for improved measurement overage and indicators of anomalies that could influence $O_3$ chemistry.
- Expand VOC and PM-OC speciation measurements to include quantitative tracers of biogenic or natural components primary OC and secondary OC vs. anthropogenic components to include at least two regionally representative rural sites and New York City.
- Measure ambient ammonia to identify its spatial and temporal distribution, source types, and its role in secondary particle formation.
- Characterize particle-size distributions in New York State on a highly time-resolved basis to identify source types and dynamics in particle production and growth. These measurements should be performed alongside detailed measurements of gaseous compounds and speciated aerosols in the ultrafine, accumulation mode, and coarse thoracic size ranges.
- Improve remote-sensing data for New York State and the region. Research is needed into multi-sensor data analysis from different instruments, which can potentially improve the spatial and temporal resolution and quality of aerosol optical data, for estimating coarse/fine-mode fractions, and separating absorbing and non-absorbing aerosols.
- Develop methodologies for interpreting satellite data in terms of air quality parameters of interest (surface quantities). For example, aerosol optical depth has been used as a proxy for surface PM2.5, but the correlation between these two measurements is complex and needs to be better understood.
- Measure PM2.5 species and gases using a high temporal resolution for better source apportionment, process studies, improved source apportionment, identification of contributions by major events (ex. wildfires), support of health studies, and trend analysis. Samples for analysis may include archived samples from previous studies, to maximize research value.

### *Topic B.1.c: Trends Analysis—Tool Development and Accountability Analysis*

**Problem Statement**
Trends analyses are needed to assess whether regulatory programs aimed at reducing pollution are having a positive impact on air quality. Determination of trends in air quality measures has been difficult because insufficient data are available to verify emission reductions, and ambient data collections are limited by spatial and temporal coverage of observations. The determination of trends is further complicated by the complexities of atmospheric chemistry, which often creates non-linear relationships between emissions and ambient observations. Innovative techniques are needed to establish credible trends.

**Research Focus**

- Develop approaches for dynamic and probabilistic evaluation of models for air quality management to determine:
    - how well models simulate changes in air quality induced by changes in weather versus emissions
    - the ability of air quality models to accurately estimate the emissions reductions needed to comply with standards

- Analyze changes in PM2.5, PM components, NOx, NOy, $NH_x$, VOCs, ozone, and other trace gases to determine trends resulting from regulatory programs (e.g., NOx SIP call, New York State Acid Deposition Reduction Act, and changes in fuel use). Approaches may include trends analysis of data from ground-based measurements and emerging remote-sensing techniques, including satellite measurements. Analysis should have sufficient temporal and spatial scope to capture the possible impacts of the regulatory implementation on ambient concentrations and exposure levels for New York State residents. A large database of measurements exists for Whiteface Mountain, Rochester, Pinnacle State Park, and Queens College and is available for trends analysis.
    - Investigate $O_3$ trends and the smaller than anticipated reduction in response downward trends in emissions.
    - Conduct trends analysis of major gas and particle pollutants using National Emissions Inventory and Canadian inventories.
    - Evaluate whether and to what extent worldwide air quality impacts $O_3$ trends in NYS.
    - Investigate why long-term measurements from the Queens College site indicate a decrease in PM2.5, sulfate and nitrate but an increase in OC. What are likely sources or atmospheric processes that have resulted in this observation?
- Perform accountability analyses to evaluate how changes in regulations, policies, technology or energy use patterns change emissions, and effect local or regional air quality, exposure, and public health. One consideration is to follow a population during a period of this change. This topic relates to Topic B.3. Exposure and Health Effects.

### *Topic B. 1.d: Integrated Air Quality Observations for Improved Air Quality Forecasting*

**Problem Statement**

Because regulations now require spatial prediction, there is a need for an integrated air quality observation system that coherently brings together air monitoring measurements and 3-D chemical transport models for better air quality forecasts. The ultimate system will be able to make air quality predictions with multiple observations from different platforms. Of particular energy relevance are those times of high electricity usage coinciding with stagnation events.

**Research Focus**

Research is needed on the development of a regional, integrated air-quality monitoring system in and around New York State to meet NYS air quality regulatory and policy needs. This would require the creation of partnerships to pull together ongoing research and development in surface sampling and speciation, remote sensing of aerosol and trace gases (including satellite measurements), and chemical transport modeling. This research topic also relates to Topic B.2.c and Topic B.2.d, which focus on improved emissions estimates.

### *Topic B.1.e: Multi-Pollutant Air Quality Management Strategies*

**Problem Statement**

There are a number of cases where full accounting of scientific knowledge would have guided decision makers to different strategies for air quality management. One example is the early choice for VOC reductions to control O3, which did not achieve expected O3 reductions, rather than combined NOx and VOC control. Currently, state implementation plans are designed around individual pollutants. However, air quality management appears to be more effective and efficient if plans are designed on a multi-pollutant basis, including criteria pollutants, hazardous air pollutants (HAPs), and climate-forcing agents (Topic C.2.d). This approach would apply to development of emission controls for energy production and use, including emerging technologies and mobile sources. The technical basis of such an approach needs to be evaluated in a New York State context.

**Research Focus**

- Examine potential opportunities for optimizing emission controls for interrelated pollutants (O3, PM, and their precursors, mercury, greenhouse gases, etc.) in New York State and the region while minimizing potential adverse side effects (e.g., local vs. regional emission reductions).

- Explore reactivity-based control strategies and potential effects on regional ozone and secondary PM formation. This should include strategies for optimizing control measures for specific source types (with consideration of new energy technologies and fuel changes) on NOx, NOy, VOCs, O3, SO2, and other photochemically active trace gases.

## B.2. Source Characterization, Pollution Control Technologies, and Emissions Inventory

There is a need to improve the quality of emissions inventories that are widely used for multiple applications, including air quality planning (through modeling), air quality forecasting, trends analyses, source attribution studies, human exposure studies, and accountability-type studies. Most electric generating units are well characterized due to continuous emission monitoring. Efforts here should emphasize those source types related to energy production and energy use that are currently not adequately characterized, including back-up generators, distributed generation technology, commercial use of residual oil, mobile sources, and residential wood combustion. Emissions estimates need to be made on finer spatial and shorter temporal scales and to establish chemical speciation of emissions (with focus on speciation of emissions for both primary fine PM and VOCs).

### *Topic B.2.a: Emissions Inventory—Better Characterization of Currently Poorly Characterized Sources*

**Problem Statement**

Much of the current emissions inventory is based on emission factors that in some cases are 20 years old. Due to changes in technology, activity patterns, and emissions of interest, there is a need to evaluate the current inventory to identify those sources that are poorly characterized and to improve the inventory by improving emissions factors and activity data. The assessment by NARSTO, "Improving Emission Inventories for Effective Air Quality Management Across North America," identified many areas in need of improvement. Since the time of that report, there have been changes in fuels used or their activity patterns. Due to regional variations in air quality and source types, and the cost of measuring emission factors, efforts to improve the emissions inventory should have a regional focus and involve U.S. EPA and adjacent states and provinces.

**Research Focus**

Research should focus on those emissions inventories with greatest uncertainties. Examples of energy-related sources in need of improved inventories are: stationary diesel engines; mobile sources, including non-road equipment; marine vessels; locomotives; residential wood combustion; stationary commercial and residential boilers and furnaces; and electrical generating peaking units. Emissions of primary particle size, speciated PM emissions, PM precursors, $O_3$ precursors, VOCs, NMOCs, hazardous air pollutants, and ammonia were identified as high priorities for improvement. Information from this evaluation should inform source characterization research priorities where possible. This characterization includes understanding emissions outside the average operation such as upsets, start-ups, and shut-downs. In addition, emissions from back-up generators need better characterization because of their use on high-electricity-demand days. Satellites and other remote-sensing techniques may provide improved measurements of temporal variability in emissions.

### *Topic B.2.b: Emissions Inventory—Micro-Inventory*

**Problem Statement**

Emissions inventories tend to represent broad geographical areas and relatively long time intervals. As a result, the data are of more limited value to air quality modeling and exposure studies on shorter time intervals. There are localized geographical areas of high emissions density where concentrations cannot be predicted by the inventory. These hotspots often are located in densely populated areas. Exposure to residents is a result of many individual sources, such as commercial buildings burning residual oil for domestic hot water and space heating, highly congested roadways, construction equipment, and industrial facilities. Changing energy-use patterns, emerging technologies such as combined heat and power, condensing boilers, and increased use of low-sulfur fuels, liquid bio-fuels or biomass fuels will change source profiles from buildings. Improvement in the inventory of emissions sources, fuel types, and activity patterns is essential for improved pollution-mitigation planning, air quality forecasting, and exposure assessments.

**Research Focus**
Develop "micro-inventories" through pilot-scale studies (including method development) with the goal of improving or ground-truthing the current inventory (e.g., boiler size, commercial activities, back-up generators) and supporting concurrent or subsequent exposure studies at the community-level scale. These studies must resolve and/or estimate the emissions at much finer spatial (a few hundred meters) and temporal (an hour or less) scales than traditional inventories, which are generally at the county level and are based on annual or seasonal averages.

### *Topic B.2.c: Emissions Inventory—Improved Estimation of Seasonal Emissions*

**Problem Statement**
Energy-related emissions vary seasonally depending on fuel use, fuel availability (e.g., wind and solar), home heating needs, transportation patterns, electrical demand, natural sources and meteorological conditions. Improved emissions inventories are needed to adequately describe these changes and improve emissions estimates. One special case is high-electricity-demand days (HEDD). These days occur during the summer when conditions are very hot, air conditioning use increases, and the demand for electricity is very high. This leads to emissions of PM and ozone precursors at levels higher than modeled by air quality planners, due to increased generation at some plants and the start-up of "peaking" plants (often combustion turbines or diesel engines) to meet the increased load. To add to the situation, back-up generators in highly populated areas that have much higher emissions rates than central station plants are used to curtail load on the electrical grid. The meteorological conditions are generally stagnant for a few to several days, preventing emissions from dispersing quickly. This results in high ozone and PM in the ozone transport region, often close to or exceeding the NAAQS. Improved emission estimates are needed for these days in order to develop emissions-reduction strategies, including increased energy efficiency and renewable energy, and to improve air quality forecasting.

**Research Focus**
Substantial improvements in systematic estimation of emissions by season using innovative methods are needed, with high spatial and temporal resolution.

Research should build upon the recent work done by the northeastern states on the quantification of emissions on high-electricity-demand days. In addition to emissions from single-cycle gas/oil turbines, speciated emissions from oil- and gas-fired boilers and stationary diesel engines should be quantified. Where practical, these efforts should be coordinated with the micro-inventory effort. Research is also needed to identify the meteorological and other conditions that result in the operation of these peaking units, as well as emissions from start-up and shut-down operations. Understanding these conditions can provide the basis for more accurately predicting emissions from these units.

### *Topic B.2.d: Source Characterization—Improved Emission Factors and Activity Patterns*

**Problem Statement**
Current emissions inventories are lacking detailed source-emissions profiles (including chemical speciation of emissions, primary particle size distributions, VOCs, and HAPs) and activity patterns with adequate time resolution.

**Research Focus**
Studies are needed to improve the quality of emissions profiles and activity data for those point, area, and mobile (on-road and off-road) sources for which current data are missing or inadequate and to examine emerging technologies. More-sophisticated emissions profiles need to be developed with other stakeholders using dilution sampling for both VOCs and fine PM. Examples of energy-related sources

include back-up generators, distributed generation technologies, industrial boilers, construction equipment, residential fuel use (including wood), outdoor wood boilers, and commercial/institutional sources of combustion. Wood combustion for example is an important source of PM2.5 and wood heating is increasing as oil prices increase. EPA's National Emissions Inventory indicates that residential wood combustion is a much larger source of primary PM2.5 in NYS than either the power or mobile sectors. Some regions such as Keene, NH have ambient PM2.5 concentrations close to the NAAQS. The largest contributor to PM2.5 in this area is wood smoke. The biomass heating industry has a vision to displace 25% of all heating oil in the Northeast with renewable energy – mostly wood heating. This will greatly increase PM emissions potentially creating near-source exposure issues or NAAQS violations. The effort to improve emission factors should be driven by regional needs and should take into account changes in combustion technologies, control technologies, fuels, and technologies to facilitate future emissions-trading opportunities.

Where possible, in-use emissions should be measured to compare with tabulated emission factors (e.g., AP-42 values). This will improve the emissions profiles, the inventory, and air quality management. In-use mobile-source emissions characterization studies are examples of the types of studies that are essential because they provide data about rapidly transforming emissions (particle formation and chemical reactions) in air pollution hot-spots. Such hot-spots are not well characterized by regional monitors and are of limited use in identifying the need for pollution mitigation strategies (such as diesel-emission reduction technologies) and exposure studies. This type of study will also support accountability assessments.

### *Topic B.2.e: Source Characterization—Improved Emission Measurement Method Development*

**Problem Statement**

Improved sampling instrumentation and chemical measurement technologies are needed to better quantify primary PM and gaseous emissions from stationary stacks, mobile tailpipes, and area sources. In addition, improved chemical speciation is needed. For example, characterization of individual hydrocarbon emissions rather than total VOCs is needed for more source types. Instrumentation for speciated organic PM would also be an improvement over OC measurements and would serve to advance air quality planning.

Beyond improved instrumentation, measurements are needed for sources under varying operational conditions such as start-up and variable loads. Measurements should also be developed under different (seasonal) ambient conditions.

Additional technologies are evolving that could help measure emissions from area sources under actual conditions. Improvements in remote-sensing technologies, whether ground-based, air-based, or satellite based, may provide verification of existing inventories, improved measurement of area or fugitive sources under actual ambient conditions, and identification of new point sources.

**Research Focus**

Innovative methods are needed to characterize PM emissions with respect to composition and size for both local and regional conditions in the Northeast. Source emissions should be characterized under varying operating conditions (start-up, steady-state, shut-down, idle, cruise, partial loads, full load, etc.). Measurements should include:

- S and C emissions from petroleum sources and bio-fuels blended with petroleum products in applications including back-up electricity generators; distributed generation technologies; on-road, non-road, and marine diesel engines; and residential, commercial, and utility oil combustion;
- wood smoke from residential or small commercial operations in rural and suburban areas;
- speciated organic SVOC emissions from commercial food operations; and
- biogenic sources of gases and particles, especially wildfires and VOCs.

New methods are also needed to measure mercury (Topic A.1) and air toxics.

Demonstrations of remote-sensing and data-analysis tools are needed to assess their usefulness in:

- quantifying primary PM, precursors of secondary PM and ozone, and their subsequent transformation in short time intervals in complex urban environments;
- quantifying non-urban emissions such as biogenic emissions from area sources;
- quantifying anthropogenic (sulfate, nitrate, and VOCs) and biogenic (forest fire) emissions transported into New York State; and
- developing datasets appropriate for use with air quality models for planning and forecasting.

### *Topic B.2.f: Improved Energy and Environmental Modeling, Including Multi-Pollutant Control Strategies*

**Problem Statement**
Enhancement of New York's electricity-sector modeling capability is necessary to more fully evaluate the impacts of existing and proposed environmental regulations and policies on the electricity-generation sector. Critical issues include emissions, system operation, markets, wholesale prices for energy and capacity, allowance prices, fuel use and diversity, imports and exports, new capacity needs, new technologies, plant retirements, and system reliability. It is important to further develop and refine the capability and tools to analyze both generation and transmission systems. This capability will enable the comprehensive analysis of New York policies as well as policies developed at the regional and national levels, informing decision-makers in developing sound environmental policies.

**Research Focus**
The following are needed improvements to specific modeling capabilities.

- Improve the capability to model operation of oil/gas steam-generation units and the associated air emissions, which largely occur in the down-state non-attainment areas. Improve the model representation of overall operation of units, including fuel-switching between oil and gas, that is due to factors other than economic dispatch. Factors to consider and quantify include reliability rules, local operation requirements due to load pockets, fuel availability/supply disruptions, fuel-storage capability, start-up and ramp-up times, short-term environmental limitations, short-term price and supply expectations, extreme weather, forced outages, transmission constraints, unplanned transmission outages, and monthly, weekly, daily, and hourly load shapes.
- Improve the capability to model operation of gas-turbine peaking units and the associated air emissions that impact air quality at critical times.
- Improve the capability to model imports and exports to and from the region. Imports are largely dependent on appropriate representation of the transmission system.
- Improve the representation of new generation and transmission technologies, renewable sources and markets, end-use energy-efficiency technologies, combined heat and power, and emission-control technologies.
- Improve the capability to incorporate as model inputs the changes in power flows that may occur as a result of system changes.
- Improve the capability to develop links between various models, whereby output from one model becomes critical input for another model with a different function. For example, yearly new-generation requirements estimated by the multi-year Integrated Planning Model (IPM) can be used as input data for the detailed, single-year Multi-Area Production Simulation (MAPS) model. Another critical link is the capability to use hourly point-source emission output data from MAPS as input to the multi-dimensional episodic air quality model used by the NYS Department of Environmental Conservation.

The following are examples of specific modeling analyses that are needed.

- Model high-electricity-demand days by evaluating the hourly emissions impacts on a single design peak day to estimate impacts of controls on specific generation units, demand-response programs that temporarily reduce electricity load, and permanent demand reductions due to energy-efficiency programs.

- Model the impacts of achieving proposed energy-efficiency and renewable targets and proposed appliance and equipment standards.
- Model the impacts of various national and regional environmental policy proposals on New York.
- Model multi-pollutant strategies to evaluate the degree to which various programs interact with each other in achieving environmental goals.
- Model improvements in the transmission system, including new lines and new technologies.

## B.3. EXPOSURE AND HEALTH EFFECTS

Critical gaps in the current understanding of the relationships of exposure to energy-related air pollution in New York persist.

### *Topic B.3.a: Improved PM Component Exposure Characterization*

**Problem Statement**
While it is now well established that exposure to PM2.5 causes adverse health effects, what remains unclear is whether specific components of PM2.5 and associated co-pollutants are responsible for the observed effects. Atmospheric PM is a complex mixture of chemical compounds resulting from the mixed composition of numerous sources. Studies are needed to improve understanding of the relationships between exposure and health effects and specific components of PM and co-pollutants. Health effects considered may be acute or chronic health effects (i.e. acute cardiovascular, reproductive, neurological, chronic pulmonary, etc.).

**Research Focus**

- Support efforts to augment the available ambient PM speciation data in New York for use in health exposure studies. The focus should be on size and chemical components of PM2.5 and associated gas-phase organic precursors. Personal monitors and crowdsourcing may be a valuable tool.
- Review and interpret the progress in $PM_x$ exposure and health studies including exposure and health trends since the last federal state of the science report. From this evaluation, indicate the strengths and weaknesses of current state of knowledge and its application to New York conditions. Recommend key studies to address weaknesses in the state of the science.
- Projects of interest might include, but are not limited to, expansion of analytical capabilities of ongoing studies, analyses of archived samples using multi-element/chemical analysis techniques, or intensive but short-duration monitoring campaigns focused around hot-spots of particular concern.
- Projects might address relationships between personal and ambient exposure, augment and strengthen ongoing epidemiologic studies, or support source-apportionment analyses, particularly where epidemiological studies are being considered. To the extent possible, projects should use state-of-the-art analytical methods and capabilities.

### *Topic B.3.b: Localized Ambient PM and Co-Pollutant Exposure Characterization*

**Problem Statement**
While general air quality has improved over the past 30 years as a result of regulatory control programs, geographic areas exist where high-emitting or highly concentrated sources may cause consistently higher concentrations of air pollution than other areas. For example, recent health studies in New York City have shown adverse health effects associated with PM components or co-pollutants. Detailed spatial and temporal characterization of concentrations of PM components and co-pollutants is needed to aid exposure studies in areas of major sources such as residual oil-fired power plants, back-up generators,

distributed generation technologies, major express highways, warehouse staging areas with high numbers of diesel vehicles, residential communities impacted by wood smoke, or other locations heavily impacted by energy-related sources. Spatially-intensive air monitoring is needed to assess concentration gradients, contributions from important source types, exposure assessments, and potential health effects. Activities in these areas could be coordinated with or extend research conducted as part of a micro-inventory (Topic B.2.2).

**Research Focus**

- Assess the potential health relevance of pollution exposure hot-spots in New York State. There should be a defined residential or occupational population nearby that is potentially impacted by the hot-spot. These might include, but would not be limited to, areas in and around the port of New York, particular neighborhoods impacted by high-volume road traffic, areas affected by a high density of diesel generators or power production or villages, or neighbors impacted by high concentrations of wood smoke.
- Characterize the spatial and temporal patterns of concentrations in the vicinity of the hot-spot, e.g., through receptor modeling efforts, by spatially intensive air monitoring, or personal monitoring to characterize personal exposures and to assess human health risks.
- Review and interpret current status of studies investigating the combined exposure to $PM_x$ and $O_3$ (possibly including PM speciation and other oxidants) applicable to New York urban and non-urban conditions.

### *Topic B.3.c: Accountability Studies for Programs Aimed at Reducing Exposure and Improving Public Health and Air Quality and Health Impact Assessments for emerging sources to prevent increased emissions and exposure*

**Problem Statement**

Studies are needed to perform an analysis of whether efforts to reduce air pollution concentrations have yielded measurable improvements in exposure and human health. Regulatory programs are focused on reducing source emissions. However, there are also emerging sources such as wood heating that will greatly increase PM, CO and other emissions from the heating sector. Full accountability will link emission reductions to reductions in ambient concentrations, personal exposures, and health and ecosystem effects to determine the effectiveness of the regulatory actions.

**Research Focus**

- Undertake studies to analyze and/or model exposure and health changes in response to regulatory programs or market effects (i.e. fuel switching, reduction of S in gasoline, or increased use of wood heating) impacting air quality in New York State. Proposals should clearly define the regulatory program of interest or changing energy market and have a plan with sufficient temporal and spatial scope to capture the possible impacts of these regulatory or market changes on ambient concentrations, human exposures, and health risks for New York State residents.

### *Topic B.3.d: Exposure Model Development for Urban, Rural and Regional Assessment*

**Problem Statement**

New experimental designs are needed to conduct studies that will lead to improved exposure models that can be linked with air quality models, especially for population centers. Advancements in human health studies will depend on an improved ability to estimate population exposure, taking into account activity patterns and varied exposure conditions. For example exposure model development needed include mobile emissions exposure in locations that are close to major roadways, long-range transport of ozone and PM, and increased exposure of rural populations to wood smoke. Some of this will require sophisticated micro-environmental air quality modeling that will be site specific.

**Research Focus**

Some areas of New York State are in non-attainment for current ozone and PM2.5 NAAQS. Large proportions of the state's population reside or work in current non-attainment areas. The NAAQS are expected to continue to tighten over time or possibly to include sub-daily limits. There are few air quality monitors in rural locations but health –relevant sub-daily ambient concentrations have been observed. An improved ability to model exposure linked with air quality models is needed. Model verification with pilot studies will also be needed.

### *Topic B.3.e: Development and Demonstration of Real-Time Personal Speciation Monitors*

**Problem Statement**

Personal exposure is a function of an individual's proximity to many sources and time spent in daily activities. The air quality of geographical regions near important local sources is not well represented by the network of monitors developed for characterizing air quality for a broader region. Recent advances in sensors and nanotechnology have revolutionized our ability to detect a wide range of materials in near real-time. However, currently available personal monitors are based on technologies that are 30 or more years old. A need exists for the development and demonstration of personal monitors to measure PM components and co-pollutants over short time intervals using miniature, light-weight monitors.