Air Toxics Health and Risk Assessment - Program 42

Program Overview

Program Description

The Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to, if necessary, regulate hazardous air pollutants (HAPs or air toxics) emissions from power plants. Most HAPs research has focused on mercury, leaving analysts, regulators, and decision makers with limited data on other air toxics emissions and how these emissions vary with fuel and control technologies. Evolution of HAPs regulations provides the opportunity for applying emerging research results as well as integrated research analyses to be considered in decision making; therefore, objective examination of the scientific basis for revised standards is essential.

The Electric Power Research Institute's (EPRI's) Air Toxics Program provides a comprehensive, stakeholder-oriented approach to technical and policy-related issues and serves as a critical and highly regarded source of objective information on air toxics. It examines all aspects of trace substances, including HAPs, across multiple environmental media (air, land, and water) and conducts basic health science research to address cutting-edge questions on health effects and public health risk assessment. The program focuses on human health effects and potential risks of mercury, arsenic, and lead emissions. Work is also under way on substances of emerging concern: nickel, chromium, cadmium, and dioxins.

Research Value

The program is the designated home for basic air toxics health effects studies via all exposure routes, thereby informing other research programs within and beyond EPRI. The research program focuses primarily on quantifying the health impacts and potential risks of such HAPs as mercury, arsenic, and lead. An important emerging effort is examining the health impacts of complex exposures to ranges of chemical mixtures, such as mercury and lead, with common health effect endpoints. The objectives of EPRI's air toxics research program allow it to provide forward-looking insight into developing federal, state, and international regulatory considerations. Close consultation with federal and state regulatory technical staff allows EPRI research to adopt a proactive approach. Such anticipatory wide-ranging exploratory research allows

- representation of a broader stakeholder research perspective as the issue emerges,
- independent scientific advances that inform regulators and broaden the perspective on the technical consequences of regulation, and
- regulatory decisions based on more complete data to provide a balanced approach from multiple disciplines

Approach

EPRI's Air Toxics Program provides a key component in an integrated approach to environmental planning for power companies. The work in this program is carried out through case studies and industrywide national assessments of environmental impacts for both current and future operations. The program staff has established direct and frequent research links with federal and state agencies to exchange data and findings, as well as to plan cooperative research efforts to fill vital gaps. An exceptional record of frequent briefings to federal executive departments and congressional committees serves as a vital conduit to decision makers. The EPRI Air Toxics Program has developed professional relationships as a primary information source to federal and state decision makers on the technical interpretation of policy issues, delivering:

- comprehensive member-oriented products, from site case studies to rapid-response technical interpretation of regulatory proposals;
- groundbreaking integrative research on both well-documented health effects, such as cancer occurrence, and health effects of emerging interest (cardiovascular effects due to mercury);

- important delineation of source-receptor relationships linking impacts to particular sources and, as importantly, allowing the exclusion of other sources from consideration; and
- objective critical reviews and analysis of emerging research findings via technical briefs and integrative assessment reports.

Accomplishments

EPRI's Air Toxics Program provides recognized international expertise in HAPs and multimedia toxics transport, fate, and health impacts. Scientific results are conveyed to federal and state decision makers as well as international agencies considering multinational conventions. EPRI's air toxics research has served as a model cited for parallel analyses by others, including government agencies. The program has an established record of providing research results through open peer-reviewed literature when possible, as well as communication tools focused on key audiences. In a number of instances, public agencies have sought the adaptation of published EPRI results as a foundation for their own technical support documents on mercury and other air toxics. A key goal of the program's cooperative research effort is a high multiplier effect: significant use of EPRI resources through collaboration and guidance of joint research efforts. These joint projects have worked and shared support with EPA, the U.S. Department of Energy, various state agencies, and the National Science Foundation. Recent program accomplishments include:

- serving as sponsor and key organizer of the United Nations workgroup on mercury fate and transport;
- briefing U.S. Senate and House of Representative committees on mercury emissions, transport, deposition, health effects, and time trends;
- developing a dynamic library of communications materials interpreting key results, available to all stakeholders and communications offices;
- providing the scientific basis for re-examination of the dose-response function for arsenic;
- demonstrating regional mercury changes to state agencies considering alternative regulation; and
- interpreting and critically analyzing influential scientific papers as well as popular press reports of technical studies.

Current Year Activities

Program R&D for 2010 will focus on rigorous analyses of utility-emitted HAPs risks under current and projected operating conditions, including potential regulatory scenarios. The continued evolution of regulation, legislation, state actions, and public perceptions of risk help shape the basic and applied studies to be carried out. Specific efforts will include

- timely delivery to decision makers of thorough, unbiased scientific information on mercury, arsenic, and other hazardous air pollutants during consideration of utility HAPs management;
- better quantification and source attribution of geographically specific contributors to air and multimedia toxics exposure in the United States and internationally;
- information for and coordination with national and international agencies on the consideration of mercury, lead, and cadmium source-receptor issues and management strategies;
- further quantification of the health effects of toxicants at relevant community levels by all exposure routes;
- integrative studies of source-to-fate-to-effects pathways for toxicants of relevance;
- improved methods to quantify mercury concentration, source attribution, and exposure; and
- refined information on source attribution of utilities via improved knowledge of plume mercury chemistry reactions.

Estimated 2010 Program Funding

$3.0M

Program Manager

Leonard Levin, 650-855-7929, llevin@epri.com

Summary of Projects

Project Number	Project Title	Description
P42.001	Mercury and Multimedia Toxics	This research focuses on mercury and multimedia substance sources, fate, health effects, and risks. Site case studies and modeling of health benefits from proposed regulatory measures are based in this project.
P42.002	Arsenic, Metals, Particulate-Bound Toxics	Arsenic and trace metals are an increasing regulatory focus; the impact of multiple utility sources, stricter health standards, and wide exposure requires further research focus in this project.
P42.003	Integration, Communication, and Critical Reviews	The project is the central home for communications efforts, integrative research across sources and media, and critical technical reviews of emerging research issues. Communication with decision makers is a key product.
P42.004	Organic HAPs and Acid Gases	A common approach to vapor-phase trace emissions, their fate, their effects on health and environment, and human exposure focuses on short-term "upset" conditions and long-term low-exposure effects.

P42.001 Mercury and Multimedia Toxics (SP3395)

Key Research Question

The complex environmental cycling of mercury, and the similarity of its exposure pathways to those of other toxics like arsenic and dioxins, allows an integrated approach to their research under a common protocol. Basic science studies of exposure and dose-response regimes can be designed using similar guidelines. Many of these commonalities can be used to advantage in multipathway modeling. For these reasons, a combined programmatic approach to substances from source through health effect to risk makes the most sense. This comprehensive approach allows a more direct path to evaluating complex exposures to multiple substances with common endpoints (mercury and lead).

Approach

This segment of the research program focuses on basic science studies of mercury and other substances with critical exposure pathways in addition to inhalation. The Air Toxics Program serves as the home for both basic health effects studies and integrative assessments across all media and all sources, for toxics emitted primarily by air. The complex pathways involved require continuing coordination with other EPRI programs, particularly in water and terrestrial sciences. Modeling studies begin with the EPRI whole-atmosphere model to run future scenarios and case studies for utility toxics scenarios, and the EPRI multimedia model to examine all routes of exposure and effects. Substance-specific case studies are carried out under this project, while multisubstance issues are handled under the other projects below. All of the research results are integrated into a comprehensive environmental toxics database to support integrative studies and trend analyses.

Impact

- EPRI’s research and analyses provide cutting-edge results highly valued by the research community, regulators, policymakers, and the public.
- Program research provides member and cooperating institutions with information to support decision making, resource management, and future operations planning.
- The research informs current efforts to plan long-term monitoring of national mercury trends.
- Broadening the application of the EPRI family of air and multimedia models will allow integration with international modeling studies currently under way.

How to Apply Results

EPRI communicates research results to members on an ongoing basis, with continuing updates as research evolves. The primary provision of results in the public domain is via peer-reviewed journals and technical reports. Technical and communications staff should ensure that these results are widely communicated via interpretive EPRI technical briefs. Members should be proactive in sending stakeholders the results, ensuring that stakeholders understand those results, and suggesting that results be incorporated into decision making related to improving public health. In addition, EPRI facilitates broader awareness of research results by briefing key stakeholders, including federal and state regulatory and research agencies; developing materials for use by specialty media; keeping EPRI's public website current; and continuing EPRI staff service on national and international advisory panels.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Mercury Deposition in Coastal Regions: EPRI's current mercury research in the southeastern United States consists of several independent studies: 1) measurement of mercury dry deposition at several sites, 2) event-based wet deposition sampling of trace metals around Plant Crist, and 3) measurement of several halogen species to understand their potential for oxidation of mercury and thus for enhancing wet deposition. The results of these independent studies will need to be combined with meteorological interpretations and model output to get a better portrayal of the highly enhanced mercury wet deposition in this region, as observed by the Mercury Deposition Network stations. Results can be applied to other coastal regions, a critical need for food fish harvest areas.	12/31/10	Peer Literature
Sources and Sinks for Atmospheric Mercury: In-Cloud and Precipitation Processes: A good deal of research on atmospheric mercury has focused on quantifying poorly understood sources of airborne mercury. It has become evident from the patterns of mercury deposition that the linkages between source and receptor may not be directly related to mercury deposition processes. A focus on potential tropospheric reaction "sinks" for various mercury species is therefore a critical step in quantifying the cycling of mercury through the regional atmosphere and ultimately through the global environment. This project will focus on the tropospheric sinks of the various airborne mercury species as the next step in quantifying mercury cycling in heterogeneous and homogeneous microenvironments. The work is exploring in-cloud and precipitation aspects of the global mercury cycle and developing a mercury analyzer suitable for airborne platforms that measures all three forms of inorganic mercury (elemental, reactive, and particle-bound) simultaneously.	12/31/10	Peer Literature

P42.002 Arsenic, Metals, Particulate-Bound Toxics (SP0357)

Key Research Question

Community exposure to trace metals and organics (such as dioxins) is of critical importance to the electric power industry. Changes in the regulatory risk assessment process, including recent findings by the National Academy of Sciences (NAS), may lead to substantial changes in the technical approach to risk assessments. These changes may include new health criteria and EPA guidelines on characterization of uncertainties, alternative default assumptions, common approaches to cancer and noncancer risk, and requirements to consider cumulative risk from many stressors. These have the potential to alter the practice and burden of risk assessment with impacts across the private sector. This project is charged with basic scientific approaches to the spectrum of health effects of particle-bound trace substances. Results are used to inform decision makers

on health risk assessment and to support science-based policy by reducing uncertainties. The goal is informed selection of protective regulatory measures that incorporate the most effective levels of control.

Approach

The focus of the health effects research is to address uncertainties in biological health effects for trace and transition metals. In the absence of detailed scientific information, health assessments rely on conservative default assumptions. One recent example is the work on arsenic health effects at low dose, which has focused on data on community levels of exposure and potential nonlinearities in cancer dose-response curves. The work is developing a comprehensive biological model based on laboratory studies. The emerging federal requirement to address risks of multichemical exposures requires such basic toxicological and epidemiological data. A particular focus is the quantification of pathways involved in toxicological responses to low-dose metal mixtures. In addition, quantifying “background” levels in cumulative risk assessments (particularly for arsenic) will also be required. By first describing the current data for metal-specific effects, and then developing frameworks to integrate these data into health effects values and assessments, EPRI will better inform this emerging regulatory process.

Impact

- Focuses on resolving the basic uncertainties and critical data gaps not addressed by other research. This information is critical to exposure and risk assessments in this and other EPRI programs in water and terrestrial studies.
- Provides improved information to assess the incidence of cancer and noncancer health endpoints ascribed to mercury and other metals.
- Reduces uncertainties in key assumptions for health risk assessments, leading to greater accuracy and less reliance on conservative default factors. More-accurate science can lead to reduced costs for protective compliance measures.
- Applies cutting-edge science and technology, such as computational toxicology, to evaluate arsenic health effect results.
- Supports research designed to set reasonable yet adequate public health standards by evaluating their factual basis.
- Provides analysis of the changing application of toxicological and epidemiological health data in the regulatory risk process.

How to Apply Results

EPRI communicates health research results to members on an ongoing basis, via continual updates across the scientific community. The primary route of application is via publication in the peer-reviewed literature. The publication of results in the peer literature is prerequisite to its adaptation by regulatory agencies, particularly at the federal level, such as the EPA IRIS toxicity database. The use of open publications substantiates the application of results for application to case studies and its further communication to state agencies. EPRI facilitates broader use and awareness of the results by briefing key stakeholders, including EPA and other federal agencies; developing materials for specialty media; keeping EPRI's public website current; and continuing EPRI staff service on national and international advisory panels.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Cumulative Risk Assessment Methodology for Metals: Incorporation of Non-Chemical Stressors: As described by EPA and recommended by NAS, cumulative risk assessment requires the combining of risks posed by aggregate exposure to multiple chemical agents and other health stressors (including chemical, social, physical, and nutritional). NAS recommends that EPA develop simplified risk-assessment tools to permit screening-level analysis at the community level, tools that incorporate non-chemical stressors, population variability, and background risk. This deliverable aims to help inform the EPA process of developing appropriate methodology as well as defaults for considering exposure patterns, background processes, and multi-stressor interactions.	12/31/10	Peer Literature
Arsenic Dose-Response Characteristics: As the work on arsenic's biological effects at low and medium doses continues, a more precise picture emerges of the consistency of the dose-response curve in the transition to low, community-relevant doses. The critical issue of slope change—that is, nonlinearity in the shape of the curve—has a direct impact on the calculated exposure dose and response in human exposures. This deliverable will integrate the in vivo and in vitro work carried out in previous years for an initial look at the dose-response results.	12/31/10	Peer Literature

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Data Constraints in Integrating Mode of Action Criteria into Dose Response Modeling for Metals	12/31/11	Peer Literature
Identification of Sensitive Cellular Targets for Methylmercury and Lead in Mode of Action Assessments	12/31/11	Peer Literature
The Influence of Non-Threshold Dose-Response Assumptions for Non-Cancer Health Effects Assessments of Metals	12/31/12	Peer Literature
Quantification of Methylmercury-Lead Interaction Across the Dose-Response Range	12/31/12	Peer Literature

P42.003 Integration, Communication, and Critical Reviews (SP3396)

Key Research Question

This project is home to the air toxics communications and integration effort—the numerous technical and background publications, issue briefs, interpretive documents, critical reviews, news items, and notices to members in air and multimedia toxics and related areas. The critical review work includes briefings to decision makers and stakeholders, research results presentations, and stakeholder webcasts. It is vitally important to continually initiate, update, and expand these products as research progresses and results are published in the technical literature by EPRI and other researchers. In addition, EPRI has the responsibility to clarify and supplement results and interpretation of results announced by others, often issued rapidly and without sufficient insight into the meaning of findings. This work is viewed as "due diligence" by EPRI as part of its mission to inform the public via unbiased, thorough, and wide-ranging research and research interpretation.

Approach

The EPRI scientific staff is closely involved with national and international research review, planning, and interpretation activities through professional societies, national and multinational agencies, and various research steering groups. EPRI staff members serve as reviewers of outside work submitted to technical journals. In addition, EPRI is continually reviewing research issued in the scientific and popular literature. As these findings are brought to public attention, EPRI prepares both technical and popular research interpretation documents to put these findings in context. Coordination with EPRI members helps to transmit these products to the public, regulatory bodies, and other stakeholders.

Impact

- Rapid and thorough peer-reviewed interpretations of new findings in environmental research and management
- A spectrum of documents and communications to address a range of audiences, from the public to technical leaders
- Important critical reviews of research results, allowing reasoned, thoughtful input to public debates and response to queries from decision makers
- Communication efforts that inform national and regional debates on regulatory initiatives related to mercury, arsenic, and other air toxics
- Credibility and objectivity that allow EPRI to work closely with regulators, policymakers, and the scientific community in sharing research results and conducting joint studies

How to Apply Results

EPRI communicates research results to members on an ongoing basis, allowing for continual updates as research evolves in association with the broader scientific community. Once these results are released in the public domain via peer-reviewed journals and technical reports, EPRI and member technical and communications staffs should ensure the results are widely communicated. Members should be proactive in sending key stakeholders the results, ensuring that stakeholders understand those results, and suggesting that results be incorporated into decisions related to public health outcomes. In addition, EPRI facilitates broader use and awareness of the results by briefing key stakeholders, including EPA and other federal agencies; developing materials for specialty media; keeping EPRI's public website current; and continuing EPRI staff service on national and international advisory panels.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Critical Air Toxics Reviews and Updates: The scope of critical reviews and research updates is being broadened and made more frequent to incorporate emerging issues in the air toxics field. These issues will include both technical updates on published research, and notice to members of emerging policy and decision milestones likely to impact future research directions.	12/31/10	Technical Resource

P42.004 Organic HAPs and Acid Gases (060355)

Key Research Question

Utility emissions of acid gases are typically at levels orders of magnitude greater than other trace substances. The utility emission rates of hydrogen chloride and hydrogen fluoride, relatively high compared to many other HAPs, are matched by their (currently) moderate toxicity levels per unit concentration. The other segment of toxicants emitted in vapor-phase form is primarily complex organic compounds, from simple substances such as benzene to complex polycyclic aromatic compounds and, still uncertain, dioxins and furans. These substances are typically issued at much smaller mass rates but higher specific toxicity. The common vapor-

phase form of these latter substances and their high bioavailability suggest treatment under a common risk-based framework, even though their origin differs from the acid gases by their formation within the combustion process. Their very different set of exposure pathways and health effects modalities require more specific approaches as warranted.

Approach

The key approaches to vapor-phase acid gases and organics require a detailed look at both acute (short-term peak exposure) and chronic (longer-term average exposure) concentration patterns. The specialized tools to quantify such exposures are difficult to assemble and apply, particularly for community exposures. Much of the work in 2010 will be devoted to developing these specialized measures for application under a variety of environmental conditions. Among these is the need to evaluate short-period operational changes in power plants; there is evidence of some organics peaking during moderate temperatures at start-up, shutdown, and plant cycling. This evaluation requires models that consider short-term but peak-value exposures.

Impact

The focus on risks under both current and future operations requires development of better data on

- organic and vapor-phase emission factors,
- acute health effects (particularly for repeated short-term exposures), and
- flexible modeling tools to evaluate these conditions in addition to chronic exposure.

Increasingly, community responses to power plant operations have involved short-term “upset” conditions, the very conditions often most conducive to secondary organic compound formation within the flue gas stream.

How to Apply Results

The wide range of conditions to be studied dictates a flexible approach to communicating results to members and the public. Evaluation of a number of operating scenarios representative of a typical operating year, with several startup and shutdown transitions per unit, can provide important findings to help bound the risks likely to result from such cycling.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Short-Term Acid Gas Concentration Patterns: As modeling methods improve and measurements of stack gas components evolve, it becomes possible to carry out case studies of short-term, high-excursion concentrations of such acid gases as hydrogen fluoride. These short-term (less than 30 minute) concentration peaks have the potential to impact nearby points at levels subject to concern regarding material damage as well as short-term exposure of sensitive human subjects in the community. A series of case studies in several source settings, selected via occurrence of unstable wind conditions and proximity of receptors of interest, will be a valuable addition to considering current and future primary and secondary air quality conditions.	12/31/10	Technical Report