Air Toxics Health and Risk Assessment

Overview

The air toxics health and risk program continues to deliver scientifically credible information for assessing the health and exposure issues associated with energy operations nationally. The work under way addresses the decision in late 2000 by the U.S. Environmental Protection Agency (EPA) to regulate the emissions of hazardous air pollutants (HAPs) from electric power generating units and the resulting program of intensive data gathering and interpretation by public and private agencies. The potential risks that might result from multimedia exposure to air toxics emissions, from power plants and from other sources, are evaluated by applying a consistent framework. By reducing the uncertainties associated with exposure and risk estimates, the program's products provide critical information for sound air toxics policy making and risk management, helping decrease reliance on overly conservative assumptions.

EPA's 2000 Mercury Research Strategy states that the agency intends to rely on EPRI research for information on mercury emissions and processes. The air toxics health and risk program is the primary vehicle for assessing the health and environmental questions related to this issue. The role of EPRI research remains that of providing unbiased technical information on mercury and other multimedia toxics in the natural and human environment. It is critical that the EPRI research program continue on its present course, focusing on mercury and other toxics of key interest, such as arsenic, dioxins, chromium, lead, and organic pollutants.

EPRI's program provides a nationally unique approach for addressing remaining key scientific uncertainties concerning the exposure, environmental fate, and potential health effects of hazardous pollutants. Research is tightly coordinated with work performed under several EPRI programs involving fuels, plant operations, water quality, and environmental control. Products include improved methods for estimating air toxics exposures, as well as better techniques and data for estimating health risks. Field methods for more accurately measuring concentrations and emissions in background environments are developed and tested for wider use by the research community in determining source contributions.

EPRI findings on mercury and other chemicals are extended and refined as new data emerge, particularly on background emissions and on human health effects. These research findings serve to constrain estimates of mercury source terms from anthropogenic emissions when compared to modeled and observed deposition patterns; the result is, over time, a reduction in the uncertainty associated with mercury source-receptor relationships.

All results are incorporated in a risk assessment/management framework and, in recognition of their time-critical nature, are efficiently communicated to program participants, regulators, and other stakeholders in a policy-relevant context. In addition to informing regulatory debates, the program's products help participating organizations assess multimedia risks and develop cost-effective management strategies for individual and grouped facilities. For example, estimates of mercury control costs that might be incurred by the electric power industry have ranged from $1.5 billion per year (EPA, 2000) to $6 billion per year (Edison Electric Institute [EEI], 1997). EPRI research has focused on evaluating whether such potential steps would in fact result in measurable lowering of mercury in food fish within a reasonable time frame, or whether "business as usual" trends in that industry might bring about comparable changes under less restrictive steps.

EPRI works closely with EPA and other regulatory agencies in this program by providing data and information directly and through the peer-reviewed literature. Participants benefit from their ability to provide guidance to the research program, to remain current on the issues and science through access to EPRI staff and contractors, and to work collaboratively among themselves and with other stakeholders through EPRI's leverage and credibility.

Projects Summary

The number and mix of projects are subject to the availability of funds. Delivery dates and content of all projects are subject to review by participants and to regulatory and technical uncertainties. In 2001, EPRI changed its "Delivery Year" end from 12/3/01 to 3/31/02. The Delivery year for 2002 will be 4/1/02 to 3/3/1/03. Project deliverables which are produced in the first quarter of 2003 are considered to be part of the 2002 program and are considered to be delivered on-time.

Project No.	Project Titles	Tracking Number	Completion Date
1	Mercury and Multimedia Substances Exposure and Risk	SP3395	2002-2003
2	Health Effects of Mercury Exposure	SP0357	2002-2004
3	Mercury Cycling and Fate: Atmospheric and Aquatic Systems	SP3396	2002-2003
4	Health Effects of Exposure to Arsenic, Nickel, and Other Air Toxics	100031	2002-2004
5	Comprehensive Risk Assessment Framework for Toxics (CRAFT)	SP0358	2003

Project Descriptions

1. Mercury and Multimedia Substances Exposure and Risk (SP3395)

Emerging survey data will be combined with regional modeling results to derive more-robust characterizations of mercury exposure via fish consumption in the United States. Use of the exposure data and models will be applied to potential alternative scenarios to assess a spectrum of changes in deposition, exposure, and fish levels of mercury in U.S. waterways.

The emergence of new data sets on emissions of chemicals from point sources, and of mercury from background sources, requires a revised assessment of emission impacts on health and the environment. This multimedia health and exposure research program develops and applies assessment tools and health risk measures for mercury and other trace substances, such as dioxins and arsenic, that have multiple pathways in the environment. Such potential pathways as children's soil ingestion can be examined with these tools. The EPRI Total Risk of Utility Emissions (TRUE) model, drawing on the basic science studies carried out, has been revised to serve as the major tool for assessment of these substances. TRUE has specialized modules for dioxin and mercury, as well as updated parameters for other multimedia substances such as arsenic. Integration of TRUE with the EPRI regional Transport, Exposure, and Assessment Model (TEAM), and with aquatic simulators such as the Mercury Cycling Model family, allows a thorough evaluation of multiple effects. A key effort will be initial work on inventory and atmospheric modules capable of simulating "multipollutant options" as one potential scenario for U.S. point sources. This work will be closely coordinated with program efforts on particulate matter, ozone, and carbon dioxide modeling.

The multimedia exposure and risk effort:

- assesses loadings to ecosystems to evaluate potential risk outcomes;
- updates food consumption and other exposure information;
- incorporates the most recent health effects findings;
- is applicable to a wide variety of site-specific settings; and
- incorporates ongoing field experiment results.

Delivery Approach: Results will be delivered through a combination of peer literature and technical reports throughout the project's duration. Many of the literature publications and technical reports will be provided to the U.S. EPA and other agencies as part of technical review activities for multimedia exposure and risk methods.

Completion Criteria and Duration: This project is currently reviewed annually by the program committee and by special technical review panels as required. Results are timed for publication by 2003 decision dates and 2004 modification dates for regulatory issues.

Deliverables

Patterns of U.S. Deposition From Model Simulations: Modeled results using TRUE will be compared with emerging data sets, and results will be presented in several peer-reviewed papers through 2002. Information will be updated frequently and made available to program participants and to public agencies.

- Peer Literature (E207857), 12/31/02

Recalculation of Mercury Exposure: New exposure data from the National Health and Nutrition Examination Survey (NHANES) IV will become available for analysis through 2004. These data will be incorporated into consumption and exposure models and, where feasible, linked to regional and local source simulations to provide more robust estimates of community exposure.

- Peer Literature (E207881), 12/31/02

Integrative Assessment, Mercury Inventory, Deposition, Cycling: Revised information on aquatic mercury cycling from EPRI field studies will be combined with analyses of fish consumption to provide detailed information for assessing exposure at community and national levels. These data will be incorporated into the EPRI modeling framework for mercury, combining regional and local scales into an integrative assessment.

- Technical Report (1005211), 03/31/03

2. Health Effects of Mercury Exposure (SP0357)

Results from this focused mercury health effects research serve to reduce reliance on unconstrained "uncertainty factors" that often introduce unnecessary conservatism into health risk estimates.

The project consists of specific studies undertaken to increase knowledge concerning the threshold for and severity of health effects of methylmercury, including reported nonneurobehavioral effects. Mercury health risk has been associated principally with neurological effects that are dependent upon the exposure dose; by definition, non-cancer effects have a threshold below which no effects are thought to occur. The most susceptible population for neurological effects is thought to be the fetus exposed in utero via maternal ingestion of methylmercury in fish. More recent concerns have focused on potential cardiovascular effects related to methylmercury exposure in adults and children, and possible immunotoxicological effects. The latter factors, plus continuing discourse concerning

validity and interpretation of neurobehavioral tests administered to populations of children, constitute remaining large uncertainties in health risk assessments for mercury.

This research:

- provides improved tools to assess neurological responses to mercury;
- reduces uncertainty in neurotoxicity testing results, leading to increased accuracy in risk estimates;
- updates program participants and other stakeholders on the latest health effects research findings, and provides perspective on likely implications; and
- applies new approaches to evaluate the validity of health effects research results.

Delivery Approach: Results will be delivered through peer literature throughout the project's duration. Many of the literature publications and technical reports will be submitted to the U.S. EPA and other health agencies, such as the National Institute of Environmental Health Sciences (NIEHS), during review activities for health effects findings.

Completion Criteria and Duration: This project is currently reviewed annually by the area council and by special technical review panels as required. Deliverables for health effects questions are basic pieces of information, each of which contributes to the total, complex puzzle of mercury health effects and helps reduce uncertainties in the biological and toxicological aspects of the problem. Deliverables are described below; completion criteria and dates for each phase of the work are listed.

Deliverables

Application of Methylmercury Pharmacokinetic Model to Focus on Uncertainties Related to Exposure and Uptake: Pharmacokinetic model applications to assess impact of variations in exposure and uptake mode on derivation of uncertainty factors in risk assessment.

- Peer Literature (E207886), 12/31/02

Performance Criteria and Uncertainties in Neurobehavioral Tests: Neurodevelopmental test battery administered to normal children and those with known decrements to diminish current high uncertainty in functional interpretation of test results.

- Peer Literature (E207887), 12/31/03

Health Risk Estimates: Concordance With Recent Mercury Health Research Results: Effects due to methylmercury exposure vary depending upon dose, target organ and concurrent exposures. Impact of recent observations in one or more of these arenas on health risk estimates is presented.

- Peer Literature (E207888), 12/31/04

3. Mercury Cycling and Fate: Atmospheric and Aquatic Systems (SP3396)

Key information is required to improve assessments of mercury emissions from background sources—both natural and altered landscapes—and the cycling and chemistry of atmospheric and aquatic mercury. New data on mercury chemistry in near-plume environments and in the free atmosphere are being integrated into the atmospheric models used, to improve simulations of transport and deposition. While these studies are in themselves critical, integration of receptor-region deposition and its time and spatial patterns will be used for model comparison and validation.

The temporal and spatial nature of atmospheric mercury sources, reactions, concentration, and deposition will be described by analyzing the growing database of historical and current measurements. New field and analytical

studies of mercury source areas and analysis of existing atmospheric mercury observations will be linked to deposition to aquatic systems. Recent research on mercury cycling in aquatic and marine systems is being used to update and verify the EPRI Mercury Cycling Model (MCM) system. This suite of models, recognized as state-of-the-art, joins models of global and regional atmospheric mercury for detailed assessments. New results from cooperative EPRI field studies will be used to refine the models. These results are key to development of regional characterization of background mercury by species, of linking emissions to fish levels of mercury, and of constraints on anthropogenic contributions to changes in future mercury levels.

Key research will be used to:

- quantify and provide national estimates for local and regional background source areas for mercury;
- clarify the role of chemical alteration in local vs. regional deposition balances;
- assess the emerging body of knowledge on mercury occurrences, past and present;
- assess the relative importance of local, regional, and global sources for various receptor regimes; and
- update state-of-the-art aquatic cycling models in MCM for new field data on processes.

Delivery Approach: Results will be delivered through a combination of peer literature and technical reports throughout the project's duration. Many of the literature publications and technical reports will be submitted to the U.S. EPA, state agencies, and international bodies during technical reviews of natural processes and impacted environments.

Completion Criteria and Duration: This project is currently reviewed annually by the program committee and by special technical review panels as required. New field results expected in 2002 will be combined with improved chemistry models for reassessments through 2003, and scenario evaluations in 2004.

Deliverables

State of Science, Background and Global Mercury Emissions: Critical uncertainties remain in regional-scale atmospheric mercury processes, including source characterization, atmospheric reactions, source-receptor relationships, and deposition patterns. Developing methods will be used to extend measurements of mercury emissions from natural sources at several sites to a continental scale. Historical patterns of deposition in sediments will be assessed in a critical review workshop in 2002 to see if time trends can be detected.

- Technical Report (1005227), 03/31/03

Refined Air Toxics and Multimedia Modeling System: Emerging atmospheric reaction mechanisms may result in altered understanding of redox rates for mercury in field environments both near and far from sources. This study will incorporate the new information on mercury atmospheric chemistry, and related data on other air toxics (such as dioxins and arsenic), into regional and local air models to improve their performance. These models include TRUE and TEAM. Mercury wet deposition measurements being made at strategic sites for the Mercury Deposition Network (MDN) will be used to test model performance.

- Peer Literature (E207889), 12/31/02

4. Health Effects of Exposure to Arsenic, Nickel, and Other Air Toxics (100031)

Health effects information on arsenic, nickel, and other trace emissions is provided to the research and regulatory community to inform and refine the health risk assessment process.

Health effects information used to date by EPA in its health risk assessment for airborne arsenic and nickel is based on studies of high levels of occupational exposure, although EPA itself has called for application of mode-of-biological-action information to estimate actual human health risk. To clarify community exposure and health

impacts, the EPRI research program develops new data to reduce uncertainties related to health effects of low exposure to arsenic in coal and nickel in oil fly ashes. Pharmacokinetic models, which are under ongoing development and application in this project, are an extremely effective means to summarize toxicological information and apply it to the all-important low-exposure scenarios that are the issue of concern in most regulatory settings. Although arsenic has been shown to demonstrate a nonlinear mode of action, current cancer risk assessment practice for arsenic is to use a linear extrapolation method, which leads to highly stringent allowable exposure levels. Application of the approach described addresses this problem. Inconsistencies in nickel cancer study outcomes are most likely related to exposure to different mixtures of nickel compounds and differing mixtures of compounds in the human studies. Other toxic substances—for example, chromium and dioxins—will be addressed as well in light of emerging regulatory issues.

This research applies new approaches to:

- establish scientific data on critical aspects of toxicological modes of action for arsenic;
- develop and advance biologically based mode-of-action models (rather than linear extrapolation from effects observed at high doses) for arsenic and nickel health risks;
- examine measures of toxicity, such as toxicity equivalence factors, and their applicability to particular source contributions, and
- provide insight into differences in research results due to nickel species in biological health mechanism(s).

Delivery Approach: Results will be delivered through peer literature throughout the project's duration. Many of the literature publications will be submitted to the U.S. EPA and other health agencies, such as NIEHS, during review activities for health effects findings.

Completion Criteria and Duration: This project is currently reviewed annually by the program committee and by special technical review panels as required. Deliverables for health effects questions are basic pieces of information, each of which contributes to the total, complex puzzle and helps reduce uncertainties in the biological and toxicological aspects of the problem. Deliverables are described below; completion criteria and dates for each phase of the work are listed.

Deliverables

Arsenic Mode of Action: Relation to Health Risk: At biologically plausible low concentrations, arsenic may exhibit protective effects. At slightly higher concentrations, its molecular mode of action may interfere with critical enzyme protein processing. This project provides novel results on mode of action and relates its impact in new health risk paradigms.

- Peer Literature (E207890), 12/31/02

Arsenic Health Risk Model Refinement: Molecular biochemical and toxicological information is applied to refine the arsenic pharmacokinetic model. Model results are then applied to improve health risk estimates based on biological mode of action rather than crude linear extrapolation methods.

- Peer Literature (E207891), 12/31/03

Nickel Pharmacokinetics: Relation to Health Risk Estimates: Biological mode of action information for different nickel chemical species is incorporated into development of a pharmacokinetic model for nickel. Implications of model findings for health risk estimates are determined.

- Peer Literature (E207892), 12/31/04

5. Comprehensive Risk Assessment Framework for Toxics (CRAFT) (SP0358)

The CRAFT framework incorporates both exposure and health risk modules to allow either screening or detailed inhalation risk assessments, depending on requirements for specificity, source inclusion, and spatial scale. CRAFT is capable of simulating a range of health effect dose-response curves with the emergence of new data.

The CRAFT risk package includes several modules for analyzing inhalation exposure and risk data on air toxics such as arsenic, nickel, chromium, and other substances. CRAFT is used for quantitatively assessing Toxics Release Inventory (TRI) information for reporting categories and risk communication activities. The component Comprehensive Risk Evaluation (CORE) model allows inhalation risk modeling of single or grouped sources for TRI assessment, for scenario testing, and for evaluation of management options. The Air Emissions Risk Assessment Model (AERAM) provides detailed assessment of an individual facility, and incorporates a health effects module for testing hypotheses concerning human response.

Delivery Approach: Results will be delivered via user manual updates and software revisions, with supporting technical reports, throughout the project's duration. Many of the literature publications and technical reports will entail model comparisons and results evaluation with other publicly available approaches, to test conservatism and realism of approach.

Completion Criteria and Duration: This project will be reviewed annually by the program committee and by special technical review panels as required. Emerging approaches to dose-response formulations will be incorporated and tested, requiring periodic revisions of methods; it is estimated that method maturity will be reached in approximately 2005.

Deliverables

Background Technical Document for Beta Model: An updated CRAFT methodology for quantifying health risks due to individual and grouped power plant air toxics emissions will be developed and extended. This update to the CORE model and the supporting modules of CRAFT incorporates new exposure and health effects data for site-specific assessments such as community demographics, future operations, and realistic exposures. Updates include the ability to calculate ranges of multipathway factors for multimedia screening and an enhanced health dose-response approach.

- Technical Report (1005224), 3/31/03

Supplemental Projects Summary

Related to this program are the following existing or proposed supplemental projects that are open for participation. As described in further detail in EPRI's policies, the results from these projects may be available only to the participants of those projects. Tailored Collaboration (TC) funds from project participants are matched by EPRI dollars, as described in further detail in EPRI's policies.

Project No.	Project Titles	Tracking Number	Completion Date
1	Mercury Cycling Critical Issues	047292	2002
2	Air and Multimedia Toxics Risk Services	103483	2002

Supplemental Project Descriptions

1. Mercury Cycling Critical Issues (047292)

Critical field studies of mercury cycling are under way in an international effort to clarify key remaining questions about management strategies.

EPRI has undertaken a series of field studies, begun with pilot studies in Canada in the summer of 1999, to answer critical questions concerning response of natural systems to changes in mercury input. Among these have been a large study of mercury transport and deposition in the Lake Superior basin; aircraft studies of mechanisms for lofting background mercury into long-range atmospheric circulation; and the dynamics of lake fish responses to changes in mercury input. These studies continue, including full-scale studies required to fully answer the key questions: How do lakes respond when mercury deposition from the atmosphere is altered? How quickly do mercury levels in fish change when inputs to their ecosystems change? And, are there key process steps or compartments that are crucial for controlling mercury movement through aquatic systems? This project opportunity will allow contributors to take part in key project reviews and be informed of preliminary results prior to formal publication in peer literature.

Delivery Approach: Results will be delivered via project updates to participants, and a final report on each effort. As always, project deliverables will be site-specific only for participants; inclusion of results in public reporting or other EPRI documents will not identify the particular host companies involved nor the particular geographic locations used.

Completion Criteria and Duration: This project will be reviewed periodically by the participants, as needed. Particular field studies are expected to be of limited duration (for example, single field seasons at remote lakes); each project final report is expected within a 12-month period from initiation.

Deliverables

Mercury Cycling Field Studies: This project enables critical elements of mercury cycling in the atmosphere and aquatic settings to go forward at critical times. Two important areas amenable to specialized funding are aircraft instrumental measurements of mercury in wildfires, and stable isotope mercury tracers in lake ecosystems. Critical resources range from advanced laboratory equipment able to discriminate among 4 or 5 trace isotopes of mercury at picogram levels, to aircraft and helicopter time for instrumental measurement of mercury aloft. The work is a key to more complete understanding of mercury in natural systems and the response of those systems to changes in mercury addition rates.

- Technical Report, 12/31/02

2. Air and Multimedia Toxics Risk Services (103483)

Trace substance releases in all media require a risk perspective to define their environmental impacts. Reporting requirements alone provide a distorted perspective on the significance of releases from normal operations.

Public reporting of substances for the federal Toxics Release Inventory (TRI) produces lists of gross mass released into the environment. The addition of federally defined persistent bioaccumulative toxic (PBT) substances such as mercury and dioxins involves exposure routes of greater complexity than those for earlier-mandated substances such as lead. Thus, TRI reporting may misrepresent the significance of such substances in the environment. For example, several previous studies by EPRI and EPA have demonstrated there is no health consequence of

significance from HCl releases from energy production. It is critical to carry out focused risk-based analyses of transport, exposure, and cycling for individual and grouped facilities to provide operating staffs with a risk perspective. These studies will be conducted as a series of case studies, looking at both inhalation and ingestion risks for mercury, arsenic, dioxins, and other key substances reportable under TRI or other requirements for the year 2002 and beyond.

Delivery Approach: Results will be delivered via project updates to participants, and a final report on each effort. As always, project deliverables will be site-specific only for participants; inclusion of results in public reporting or other EPRI documents will not identify the particular host companies involved nor the particular geographic locations used.

Completion Criteria and Duration: This project will be reviewed periodically by the participants, as needed. Particular field studies are expected to be of limited duration (for example, single field seasons at remote lakes); each project final report is expected within a 12-month period from initiation.

Deliverables

Toxics Release Multimedia Case Studies: This project will simultaneously estimate the risk consequences of large-source air, water, and solid waste releases, using EPRI-developed models such as CRAFT, TRUE, and TEAM. These case studies will maintain confidentiality of individual facilities and systems when necessary, but provide insight across the energy sector into the sensitivity of risk outcomes for given emissions and discharges. Alternative scenarios can be utilized to incorporate recent changes in operations or controls, or new findings on health effects, exposure, and chemistry. Three EPRI-developed model packages are the primary tools used in these assessments. CRAFT efficiently calculates inhalation risks from single or multiple facilities for regional assessments. The TRUE model allows assessment of environmental concentrations and rates in all media (land, air, and water), along with individual and communitywide exposure and health risk; it explicitly includes food and water ingestion, major routes of concern for arsenic, dioxins, and mercury. The TEAM model can be used to assess regional source-receptor relationships for mercury and other trace substances.

- Technical Report, 12/31/02