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Dear Environment Sector members:

We would like to thank all members who participated in the Cleveland advisory meetings, especially with regard to our priority setting and planning for the 2009 offering. From our perspective, and hopefully yours, the input we received was extremely valuable and we appreciate the thought and effort everyone expended in our first attempt at this process. We are currently sorting through the results and will be providing feedback over the next several weeks.

In this issue of *Quick News*, note that there are several articles that pertain to the issue of arsenic. This is an integrated research effort that involves several programs in Air, Water and Land/Groundwater. As this issue becomes more front burner, we intend to have our research results available as part of any regulatory process as well as help those who are dealing with arsenic remediation.

Thank you again for your energy and enthusiasm in Cleveland. We look forward to seeing you all again in Scottsdale next February or at one of our upcoming technical meetings.

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### ENVIRONMENT SECTOR

#### ***Environment Sector Peer-Reviewed Literature Status Posted on epri.com***

Spreadsheets showing the status of all articles submitted to third-party peer-reviewed publications are available on epri.com. The spreadsheets, available for each Environment Area, list articles that have been submitted or published, and give full citations for published articles. A link to the [Peer Literature](#) page is available from the Environment "Overview" page under "Portfolio." Note that EPRI membership does not include automatic web access to third-party publications, and that articles submitted to third-party publications are no longer owned by EPRI.

## Program 42: Air Toxics Health and Risk Assessment

### Progress Report: Arsenic Health Effects Research

Clewell HJ, et al. "Research toward the development of a biologically based dose response assessment for inorganic arsenic carcinogenicity: A progress report," *Toxicology and Applied Pharmacology*, 222 (2007), 388–398. EPRI is participating in collaborative research to develop a biologically based dose-response model that can be used to estimate the carcinogenicity of inorganic arsenic at the low doses commonly encountered by U.S. populations. Possible overestimates of low-dose ingestion cancer risk—based on the current linear dose-response model—could have far-reaching implications for U.S. water standards and exposure guidance values, including ambient water quality criteria and related regulatory requirements for remediation of arsenic-contaminated sites owned by electric power companies. Since inhalation cancer risk is also based on linear extrapolation, results from the current study may ultimately apply to it as well. Key areas of collaborative research include:

- **Physiologically based pharmacokinetic (PBPK) modeling.** Researchers are refining comparable models that predict dose to target tissues based on the kinetics (chemical reaction rates) of inorganic arsenic and its metabolites in mice and humans.
- **Cancer modeling.** The research paper presents a hierarchy of cellular responses across a range of doses of inorganic arsenic. With each dose, a cell enters a different state with new properties that are reflected by the alteration of genes in key signal pathways. Since—regardless of exposure route—inorganic arsenic acts through interaction with proteins rather than DNA, a model of inorganic arsenic carcinogenesis must describe both mutagenic and cell regulatory changes.
- **Literature review of genomic responses to arsenic.** Published studies have reported a consistent pattern of gene changes involving seven categories of cellular response to inorganic arsenic. In general, the effects of inorganic arsenic can be seen as highly specific direct interactions of arsenite (the trivalent form of arsenic) with critical proteins, superimposed on a background of chemical stress. At low exposure concentrations (0.01  $\mu\text{M}$ ), cells apparently enter an adaptive state. At high concentrations ( $> 5 \mu\text{M}$ ), they exhibit increased toxicity shown by cell cycle stasis, apoptosis (programmed cell death), and inhibition of DNA repair. An observed reversal of gene responses at concentrations below 0.1  $\mu\text{M}$  supports a nonlinear threshold model. Reported gene changes are consistent with epidemiologic and *in vitro* effects of arsenic seen under different exposure conditions.
- **Arsenic genomic dose-response studies.** The bladder is one of the human target tissues for arsenic carcinogenesis. The bladder was selected as the initial focus for study for technical reasons. Assuming adequate resources, the lung as a target tissue will be evaluated next. In work reported here, researchers found no significant gene expression changes in the bladder tissue of a low-dose (0.05 mg/l) group of mice exposed to inorganic arsenic in drinking water, compared with controls. Significant changes were seen in the high-dose group (50 mg/l). A 12-week follow-up study employing multiple concentrations will document changes in gene expression related to dose over time.
- **Application of biologically based dose-response model to arsenic low-dose nonlinear cancer risk assessment.** As an alternative to a linear extrapolation approach, a nonlinear margin-of-exposure approach that maintains a biological basis will be developed. This margin-of-exposure approach will be built on the relatively uncomplicated biologically based dose-response (BBDR) model developed by this project. The BBDR model incorporates multiple gene expressions associated with events that must occur for tumors to develop as a result of inorganic arsenic exposure.

This research is being performed under a Memorandum of Understanding among EPRI, The Hamner Institute (formerly CIIT Centers for Health Research), and USEPA. For more information, contact Leonard Levin, (650) 855-7929, [llevin@epri.com](mailto:llevin@epri.com).

### Arsenic Project Appoints Scientific Review Panel

Five well-known arsenic researchers have accepted an invitation to serve on a scientific review panel for the joint arsenic research project undertaken by EPRI, The Hamner Institute (formerly CIIT Centers for Health Research), and USEPA. First results from the 3-year project (2007–2009) are described in the item above. Panel members include:

- Aaron Barchowsky, PhD, Associate Professor, Department of Environmental and Occupational Health, Graduate School of Public Health, Pittsburgh, PA
- Barbara Beck, ScD, DABT, Gradient Corporation, Cambridge, MA
- Samuel Cohen, MD, PhD, Professor of Pathology and Microbiology, University of Nebraska Medical Center, Omaha, NE
- Toby Rossman, PhD, Professor of Environmental Medicine, School of Medicine, New York University, Tuxedo, NY
- Miroslav Styblo, PhD, Research Associate Professor, Department of Nutrition, University of North Carolina, Chapel Hill, NC

Panelists will meet periodically with investigators as the project progresses. Drs. Barchowsky, Rossman, and Styblo served with EPRI consultant Dr. Janice Yager on the USEPA Science Advisory Board Arsenic Review Panel responsible for the June 2007 report [Advisory on EPA's Assessments of Carcinogenic Effects of Organic and Inorganic Arsenic: A Report of the US EPA Science Advisory Board](#). For more information, contact Leonard Levin, (650) 855-7929, [llevin@epri.com](mailto:llevin@epri.com).

## **Program 91: Assessment Tools for Ozone, Particulate Matter, and Haze**

### ***New EPRI Project Will Link AMSTERDAM and WARMF Models***

Air quality models, such as the EPRI-funded AMSTERDAM model, and watershed models, such as EPRI's WARMF, are typically applied independently by different groups to simulate atmospheric pollution and land/water ecosystem impacts, respectively. The end point of the air models is generally the starting point of the watershed models, but little effort has been made to link them in a rigorous manner. Linkages would allow researchers to follow the path of pollutants emitted into the air, their transport and transformations in the atmosphere, their deposition to the earth, and their fate in water bodies/watersheds after interactions with other anthropogenic and biogenic matter. The linked models could be used to evaluate the water quality improvement that would result from the reduction of specific air emissions from specific power plants—a capability that does not currently exist. Therefore, EPRI has undertaken a new Technology Innovation (TI) project to develop an interface between AMSTERDAM and WARMF. Design of the interface will address the following issues:

- specification of the spatial domain and time period for testing the interface
- spatial scale and projection conversions
- temporal resolution
- file format specifications
- mapping of chemical species from AMSTERDAM to WARMF
- mapping of meteorological model results used in AMSTERDAM for use in WARMF
- deposition and air concentration results from AMSTERDAM for use in WARMF

The design, coding, testing, and documentation of the interface is expected to be complete by the end of 2008. For more information, contact Eladio Knipping, (650) 855-2592, [eknippin@epri.com](mailto:eknippin@epri.com), or Robert Goldstein, (650) 855-2593, [rogoldst@epri.com](mailto:rogoldst@epri.com).

### ***EPRI Attends Planning Meeting for California Air Quality/Climate Change Field Study***

EPRI researcher Eladio Knipping attended a planning meeting held Sep. 21 in Sacramento, CA, sponsored by the National Oceanic and Atmospheric Administration, the California Air Resources Board, and the California Energy Commission. The purpose of this public meeting was to begin the planning process for a possible combined air quality and climate science field study in California in 2010. EPRI is interested in learning more about the field study, determining how EPRI might participate or collaborate in the funding or execution of studies, and exploring which issues to be addressed in California might be of broader interest to EPRI members throughout the nation. For more information, contact Eladio Knipping, (650) 855-2592, [eknippin@epri.com](mailto:eknippin@epri.com).

## Program 92: Assessment of Air Quality Impacts on Health and the Environment

### Two Articles Based on TERESA Research Published

Two articles based on research conducted under EPRI's Toxicological Evaluation of Realistic Emissions of Source Aerosols (TERESA) study have been published in the journal *Inhalation Toxicology*.

- P.A. Ruiz, J.E. Lawrence, J.M. Wolfson, S.T. Ferguson, T. Gupta, C.-M. Kang, and P. Koutrakis. "Development and evaluation of a photochemical chamber to examine the toxicity of coal-fired power plant emissions." *Inhalation Toxicology* 19 (8): 597-606 2007. When investigating the toxicity of individual particle sources, it is important to consider the contribution of both primary and secondary particles. The authors present the design of a new photochemical chamber that can be used to form secondary sulfuric acid particles from diluted coal-fired power plant emissions. The chamber is a relatively small, well-mixed flow reactor that can fit in a mobile reaction laboratory. It produces high concentrations of hydroxyl radical (OH) from the photolysis of ozone (O<sub>3</sub>) in the presence of water vapor. A pilot chamber was tested in the laboratory, using mixtures of NO and SO<sub>2</sub> in air, at concentrations approximately 100 times lower than those in power plant stack emissions. This chamber was able to oxidize about 20% of the SO<sub>2</sub>, thereby producing 1350 µg m<sup>-3</sup> of H<sub>2</sub>SO<sub>4</sub> particles. Further tests showed that increasing O<sub>3</sub> concentrations and residence time increased the H<sub>2</sub>SO<sub>4</sub> production. A field chamber was built subsequently and used in a toxicological study. Diluted coal-fired power plant emissions were introduced in the chamber. Over 19 days of exposure, the chamber, on average, converted 17% of the supplied SO<sub>2</sub> emissions and produced an average of 350 µg m<sup>-3</sup> of H<sub>2</sub>SO<sub>4</sub> particles. Particle losses were determined for the pilot chamber, using artificial particles whose size ranged from 50 to 1000 nm. The determined losses ranged from 21% to 42%, with no trend between the amount of particle loss and particle size. Losses for the field chamber, estimated using model calculations, were found to be similar to those of the pilot chamber.
- P.A. Ruiz, T. Gupta, C.-M. Kang, J.E. Lawrence, S.T. Ferguson, J.M. Wolfson, A.C. Rohr, and P. Koutrakis. "Development of an exposure system for the toxicological evaluation of particles derived from coal-fired power plants." *Inhalation Toxicology* 19 (8): 607-619 2007. To investigate the toxicity of particles originating from coal-fired power plants, it is necessary to consider the effects of both primary particles and secondary components formed in the air through atmospheric reactions. The authors describe a new exposure system that can be used to expose animals to both directly emitted particles and secondary particles. The system consists of three main components. The first is a sampling system to continuously collect and dilute power plant stack emissions. The second is a reaction laboratory that contains reaction chambers to simulate atmospheric reactions. The following atmospheric reactions were simulated: (1) the oxidation of sulfur dioxide to form sulfuric acid, (2) the neutralization of sulfuric acid by ammonia, and (3) the reaction of α-pinene with ozone to form secondary organic aerosol. Using these chambers with the diluted emissions, different typical atmospheric scenarios can be simulated. The final component is a mobile toxicology laboratory where animals are exposed to the resulting test aerosols. The authors report the characteristics of the test aerosol exposures obtained at a coal-fired electric power plant. Particle exposures were characterized for concentrations of mass, elements, elemental carbon, organic species, inorganic ions, strong acidity, particle number, and size distributions. Mass concentrations ranged from a few micrograms per cubic meter for a scenario of primary emissions only, to about 250 µg m<sup>-3</sup> for the most complex scenario. The authors show that the different scenarios produced a large variation in the composition of the test aerosol, thus potentially changing the toxicity of the emissions.

For more information, contact Annette Rohr, (650) 855-2765, [arohr@epri.com](mailto:arohr@epri.com).

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## GLOBAL CLIMATE CHANGE

### Visit the Global Climate Webpage

## Program 103: Greenhouse Gas Reduction Options

### Meetings and Webcasts for Climate Area Funders

Two more of EPRI's series of meetings and webcasts for Climate Area funders have been held. On Aug. 22, EPRI reprised its July 24 meeting on GHG cap-and-trade programs and allowance allocations in a webcast that involved more than 30 online participants. The purpose of the meeting was to consider the enormous

potential financial impacts of allowance allocations upon companies and their ratepayers, with amounts up to perhaps \$100 million per company (even billions of dollars for some large companies) per year at stake. Topics included the difficulties faced by the electric sector in capping emissions; differences between free allocation of allowances versus auctioned allowances; auction design and its implications; the effects of allowance allocation on electric sector costs; the advantages and disadvantages of a cap-and-trade system versus emissions taxes/fees; and distribution of impacts to customers and asset owners under rate regulation and competition. On Sep. 13, 42 individuals participated in EPRI's second Global Climate Policy Design Forum in Washington, DC, including EPRI staff, EPRI members, and GHG offset experts from organizations such as Environ, Natsource, the Natural Resources Defense Council, PointCarbon, Stanford University, and the World Resources Institute. The GHG offset workshop focused on providing members with a better understanding of the potential role that GHG emissions offsets may play in evolving domestic and international climate policies. Attendees reported that the workshop gave them a better understanding of the complexity surrounding inclusion of GHG emissions offsets and the views of different stakeholder groups on the potential role of offsets. EPRI is now planning its Third Design Forum, which will likely deal with GHG allowance auction design and is tentatively scheduled to be delivered via webcast sometime in late October. For more information, contact Vic Niemeyer, (650) 855-2744, [niemeyer@epri.com](mailto:niemeyer@epri.com); Adam Diamant, (510) 260-9105, [adiamant@epri.com](mailto:adiamant@epri.com); or Tom Wilson, (650) 855-7928, [twilson@epri.com](mailto:twilson@epri.com).

### **Supplemental Project: Analysis of CO<sub>2</sub> Policy Impacts on Western Power Markets**

[Collaborative Analysis of CO<sub>2</sub> Policy Impacts on Western Power Markets](#) (1015421). EPRI is launching a study for the Western Electricity Coordinating Council (WECC) on potential CO<sub>2</sub> policy impacts on Western power markets. Determining the impacts of climate policy on the electric power industry is a complex problem that requires considering both regional diversity and the linkages among markets for fuel, power, and emissions. To examine this complex issue, EPRI has developed an analytical framework for assessing the economic impacts of climate policy on the electric power industry, and has applied the framework to determine how specific CO<sub>2</sub> emission penalties would affect existing and proposed power plants in two prototypical regions—"Coal Land (ECAR/MAIN)" and "Gas Land (ERCOT)." Work under this Supplemental Project Notice will apply the EPRI CO<sub>2</sub> market analysis framework to the WECC system as it stands today and in future years (2015, 2020, and 2025). The intent is to develop analytical insights that will help WECC utilities evaluate investment in new generation and to communicate these insights to stakeholders. An additional goal is to explore the impact of alternative implementations of state-level policies to restrict electric-power-sector CO<sub>2</sub> emissions. The project will produce two sets of deliverables:

- General analysis results for the WECC region, including an assessment of the impact of climate policy on power prices, regional emissions, and the cash flows to new and existing fossil and non-emitting generation. These products will be available to all project funders.
- Utility-level results mapping the regional results to the assets of each participating utility, delivered in a private presentation to each participating utility's analysts and management.

The price to participate in this project is \$10,000 for entities with capacity of less than 1,500 MW, \$25,000 for entities with 1,501–4,000 MW total capacity, and \$45,000 for entities with more than 4,000 MW total capacity. Companies that fund any Environment program can use Tailored Collaboration (TC) funds for up to half their price. Six members of WECC have so far expressed strong interest, and others are encouraged to participate to increase the project's scope and usefulness. For more information, contact Vic Niemeyer, (650) 855-2744, [niemeyer@epri.com](mailto:niemeyer@epri.com).

## **Area News**

### ***Newest Climate Briefs Discuss Natural Climate Variability, Economic Implications of Carbon Cycle Uncertainty***

The most recent in EPRI's series of Climate Briefs are as follows:

- [Progress in Understanding Natural Climate Variability](#) (1014807). With uncertainty in the degree of natural climate variability, furthering our understanding and narrowing that uncertainty is critical in discerning the human influence on the observed global climate change. To help address these uncertainties and to identify ways to advance the state of knowledge regarding natural climate variation, EPRI, along with both the U.S. and

Swiss National Science Foundations, helped fund a four-day workshop entitled “Past Millenia Climate Variability: Proxy-Base Reconstructions, Modeling and Methodology – Synthesis and Outlook” in Switzerland in June 2006. This Climate Brief discusses the results of that workshop. Among these results was the conclusion that “Late 20th century warming is likely anomalous (human caused) in the context of the past 1000 years at hemispheric scales. There is evidence for periods of cooling and warming that occur on all timescales and on all spatial scales.”

- [The Economic Implications of Carbon Cycle Uncertainty](#) (1014819). The Intergovernmental Panel on Climate Change (IPCC) has concluded that atmospheric concentrations of carbon dioxide (CO<sub>2</sub>) have increased over the past century due to human activity. Further, significant increases in CO<sub>2</sub> emissions from fossil fuel combustion are expected over the next several decades. Studies to explore the economic implications of stabilizing atmospheric concentrations of CO<sub>2</sub> have traditionally ignored carbon cycle uncertainty. However, the economic cost of stabilizing the concentration of CO<sub>2</sub> is highly dependent on the future rate of carbon uptake by natural processes. This Climate Brief explores how carbon cycle uncertainties affect the economic costs of achieving a given CO<sub>2</sub> concentration target.

### ***Richels Appointed to National Academies’ Climate Research Committee***

EPRI’s Richard Richels has been appointed to the National Academies’ Climate Research Committee, which is responsible for developing, coordinating, and providing oversight for climate-related activities across the National Academies (which consists of the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council). The CRC also functions as the U.S. National Committee for the World Climate Research Programme (WCRP), and as a liaison between WCRP and the U.S. Climate Change Science Program. Dr. Richels will serve a three-year term. For more information, contact Richard Richels, (202) 872-9222, [richels@epri.com](mailto:richels@epri.com).

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## **LAND AND GROUNDWATER**

### **Program 49: Coal Combustion Products—Environmental Issues**

#### ***Health and Ecological Effects of Arsenic in Soil and Water***

[Arsenic Health and Ecological Effects: Soil and Water](#) (1014015). This technical report summarizes current knowledge of the human health and ecological effects of environmental arsenic and discusses use of this information in assessing risk and setting regulatory standards. Since arsenic occurs naturally in coal, and thus in coal combustion products, arsenic risk assessment and regulation are important concerns for electric power producers. In their detailed survey of the arsenic toxicity literature, authors of the report considered non-cancer and cancer human health effects related to inorganic and organic arsenic exposure via water, air, and soil—as well as toxicity to aquatic plants and animals. Because inorganic arsenic species (arsenate and arsenite), commonly found in groundwater and soil, are much more toxic than organic arsenic compounds (monomethylarsonic acid and dimethylarsinic acid) also found in those media at much lower concentrations, the report focuses on inorganic arsenic toxicity and carcinogenicity. Exposure to high levels (greater than 150 µg/L) of inorganic arsenic in drinking water in Taiwan has been associated with cancer of the lung, bladder, and skin. Based on epidemiologic studies of Taiwanese exposed at this level, inorganic arsenic has been classified as a “human carcinogen” by EPA. However, linear extrapolation of the Taiwanese results to lower dose exposures in the United States may be inaccurate: arsenic carcinogenicity is believed to exhibit a threshold of action and/or a sublinear dose-response relationship at low doses. Further EPRI research is underway to define the inorganic arsenic dose-response relationship for bladder cancer at low dose. This research is important, the authors note, because “. . . linear extrapolation of health risks observed in arsenic drinking water studies conducted outside of the United States to lower doses likely overestimates arsenic risk for U.S. populations, where arsenic exposures (e.g., from water and food) are significantly lower and nutritional intake is different.” An accurate characterization of the dose-response relationship in the low-dose range will inform EPA’s arsenic cancer risk assessment, which is the basis for development of arsenic standards in water, soil, sediment, and air. For more information, contact Ken Ladwig, (262) 754-2744, [keladwig@epri.com](mailto:keladwig@epri.com).

## Program 50: MGP Site Management

### Supplemental Project: *In-Situ Thermal Stabilization of Coal Tar*

Companies are invited to provide TC matching credits for a bench-scale treatability study using thermal conduction heating to stabilize coal tar in contaminated soil. Study results will guide full-scale remediation at a site in Georgia where residual tar contamination lies beneath railroad tracks adjacent to a former MGP plant. The results will also benefit owners of MGP sites where full excavation of source coal tar is impractical. Thermal conduction heating works by raising the subsurface temperature to the boiling point of water, which distills off volatile organic compounds (BTEX and naphthalene) for vapor recovery and leaves the remaining coal tar as a solid, stable mass. This process will be applied in the laboratory to contaminated soil samples (fill, sand, peat, and clay) from the site to determine the lowest temperature that can meet full-scale treatment objectives while saving energy, time, and cost. Researchers will also assess soil property changes resulting from thermal treatment that could cause settling beneath the tracks. The study will start this fall with field work to refine information about contaminant distribution, collect soil samples, and characterize local hydrogeology. It will conclude in early 2008 with EPRI publication of a final treatability report. Tailored Collaboration credit matches totaling \$170,000 are needed to fund the project; the minimum contribution is \$42,500. Companies that fund any Environment program can contribute TC credits. For more information, contact Andrew Coleman, (650) 855-2249, [acoleman@epri.com](mailto:acoleman@epri.com).

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## WATER AND ECOSYSTEMS

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## Program 53: Water Quality Criteria Development and Assessment

### Progress Report: *Arsenic Health Effects Research*

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This research is being performed under a Memorandum of Understanding among EPRI, The Hamner Institute (formerly CIIT Centers for Health Research), and USEPA. For more information, contact John W. Goodrich-Mahoney, (202) 293-7516, [jmahoney@epri.com](mailto:jmahoney@epri.com).

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### **Program 54: Fish Protection at Steam Electric Power Plants**

#### ***eTherm Website Updates***

The following updates have recently been made to EPRI's [eTherm website](#).

- The Recent Developments page has been updated with current happenings.
- A new topic on Use of Reclaimed Water for Power Plant Cooling has been added under the Water Sustainability topic.
- New references on temperature investigations and fish impacts have been added to the Thermal Plume Assessment – References page.

The eTherm website is available only to members of the Fish Protection Program. For more information, contact Robert Goldstein, (650) 855-2593, [rogoldst@epri.com](mailto:rogoldst@epri.com).

#### ***Presentation at AFS on Fish Response to Fluctuating Temperatures***

Results from EPRI's study of fish response to fluctuating temperatures were presented at the 137th annual meeting of the American Fisheries Society, held Sep. 2–6 in San Francisco. The study has included lab experiments, to better define the relationships between exposure magnitude/duration and thermal stress in fish, and the role of recovery; and modeling, to simulate stress accumulation during dynamic temperature exposure. The presentation discussed the following results:

- Slower rates of increase resulted in earlier loss of equilibrium.
- Acclimation that increases thermal tolerance can happen quickly.
- The potential for acclimation and stress accumulation to occur simultaneously complicates understanding of both.
- Fluctuating temperatures are not necessarily detrimental (depending on the range) and often produce increased acclimation, resulting in higher upper limits.
- Thermal stress accumulation is not always intuitive.
- The thermal stress model should be a useful tool for evaluating the protectiveness of various types of thermal standards.

For more information, contact Robert Goldstein, (650) 855-2593, [rogoldst@epri.com](mailto:rogoldst@epri.com).

## **Program 55: Watershed and Water Resource Management**

### ***New EPRI Project Will Link AMSTERDAM and WARMF Models***

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- mapping of meteorological model results used in AMSTERDAM for use in WARMF
- deposition and air concentration results from AMSTERDAM for use in WARMF

The design, coding, testing, and documentation of the interface is expected to be complete by the end of 2008. For more information, contact Eladio Knipping, (650) 855-2592, [eknippin@epri.com](mailto:eknippin@epri.com), or Robert Goldstein, (650) 855-2593, [rogoldst@epri.com](mailto:rogoldst@epri.com).

### ***Tech Update Published on Water Quality Trading Pilot Programs***

[Program on Technology Innovation: Water Quality Trading Pilot Programs: Review of Catawba River Basin, Chesapeake Bay, and Ohio River Pilot Projects](#) (1015409). Water quality trading (WQT) has potential as an alternate means for power facilities to meet compliance goals with nutrient discharge limits, particularly for nitrogen. EPRI is working to identify and conduct a feasibility study for a WQT pilot project involving one or more power companies. This Technical Update summarizes general information on three potential pilot project locations, describes the screening criteria used to evaluate the potential of each project location, and completes an analysis of site strengths, weaknesses, opportunities, and risks for each. Three potential WQT pilot programs were reviewed and assessed: the Ohio River Basin, the Chesapeake Bay, and the Catawba River Basin. The Ohio River Program was chosen as the most promising site following an evaluation based on 11 key components for success. For more information, contact Jessica Fox, (650) 855-2138, [jfox@epri.com](mailto:jfox@epri.com).

### **Brochure on EPRI Energy/Water Sustainability Research Program Available**

“Power Generation and Water Sustainability: Technical Brief – A Research Program for the Electric Power Industry” (1015444). This four-page brochure summarizes the main points of EPRI’s 10-year energy/water sustainability research plan for the electric power industry. It discusses the five major elements of the program: engineering and economic analysis, improving dry and hybrid cooling, reducing water losses from cooling towers, use of degraded waters, and water resources management and forecasting. The total cost of the proposed research program is anticipated to be about \$37.5 million over a 10-year period. The potential benefits of using the technologies to be developed as part of this program would be substantial at the plant level. Implementing one or more of these technologies at a 350-MW baseload coal facility could raise profit margins by an estimated 1–3 percentage points. Cumulative benefits on an industrywide basis could exceed \$700 million by 2030. For more information, contact Robert Goldstein, (650) 855-2593, [rogoldst@epri.com](mailto:rogoldst@epri.com).

### **Progress on Cross-Pollutant Trading Project**

EPRI’s project examining cross-pollutant trading has to date focused primarily on identifying existing and proposed cross-pollutant trading programs, and in determining answers to three questions about each program:

- Is the trade effective in reducing the pollutant load (i.e., does the science support it)?
- Does the trade comply with the Clean Water Act (i.e., is it legal)?
- Is the trade attractive (i.e., what are the behavioral and economic outcomes)?

Three existing cross-pollutant trading programs and six proposed programs have been identified, and researchers are compiling detailed information about each. Researchers have also examined federal and state programs related to trading, including EPA’s policy—which makes specific provision for cross-pollutant trades—and policies in Michigan, West Virginia, Colorado, and Pennsylvania. Future work will focus on methods for cross-pollutant trading; of particular interest are trades related to ammonia involving reductions in pH and temperature to reduce in-stream un-ionized ammonia concentrations and related toxicity. Modeling tools that can demonstrate the effectiveness of pollutant load reductions through cross-pollutant trading will also be considered. For more information, contact Robert Goldstein, (650) 855-2593, [rogoldst@epri.com](mailto:rogoldst@epri.com).

### **Supplemental Project: Assessing Impact of Climate Change on Water Availability for Power Generation**

“Assessing the Impact of Climate Change on Water Availability for Power Generation” (1015484). Climate change and increasing weather variability can potentially create shortages of high-quality fresh water in many regions of the United States. The availability of such water is critical for thermoelectric power generation as well as hydroelectric generation. EPRI has developed an analytical framework that can help individual companies evaluate the risk that water shortages could affect their power generation capability. EPRI will customize and apply this framework to evaluate the vulnerability of individual power companies to climate-induced shortages in water availability. The framework consists of four levels:

- The first level of analysis uses detailed watershed budgets to evaluate water availability. Regional annual and seasonal inventories of water resources are assembled, and water requirements for electricity generation are also estimated and compared to other local water demands. Based on this information, conditions under which significant water availability deficits might occur are identified and analyzed.
- The second level utilizes a mechanistic watershed simulation model and addresses potential impacts of climate variability (such as droughts and heat waves). Climate scenarios are generated using random or directed selection of past weather patterns; these scenarios can then be used to identify climate-related risks to meeting electricity demands. Simulations of strategies (e.g., water sharing agreements and water recycling) and technologies (e.g., atmospheric cooling and wet cooling tower water vapor capture) to mitigate these risks can also be evaluated.
- In the third level, outputs from global climate models are used to adjust current weather patterns by applying predicted average temperature and precipitation changes. The adjusted weather patterns are used to drive the watershed model and evaluate the ability of different strategies and technologies to mitigate potential risks.
- The fourth level involves adding probabilistic analysis, in which physical watershed modeling is combined with statistical methods to quantify the risk of climate-induced water shortages. Timescales of up to 80 years can be evaluated.

The price of the project depends on the size of a participant's operations, the size and complexity of the watershed, the diversity and size of other stakeholders within the basins, and the level of analysis detail desired. Anticipated prices range from \$200,000 to \$400,000. EPRI will work with interested parties to provide a specific scope of work and a cost estimate. Companies that fund any EPRI Environment Program can use tailored collaboration (TC) funds for up to half their contribution. Companies that have not yet purchased any Environment Program may co-fund this project. For more information, contact Robert Goldstein, (650) 855-2593, [rogoldst@epri.com](mailto:rogoldst@epri.com).

## **Program 56: Effluent Guidelines and Water Quality Management**

### ***Report Published on Biotechnology R&D Opportunities in the Electricity Enterprise***

*Program on Technology Innovation: Biotechnology Research and Development Opportunities in the Electricity Enterprise* (1014706). Biotechnology offers great promise for the electricity enterprise in terms of lower cost, higher efficiency, and sustainable options through applications in areas such as biomass, bioremediation, phytoremediation, carbon capture, industrial process enhancement, biofuels and hydrogen production, and corrosion control. The electricity enterprise is currently underrepresented in the biotechnology sector in terms of research, but there is a current move to apply plant and industrial biotechnologies to the energy sector because of the enormous market potential in specific applications. This report points to opportunities where EPRI can advance such developmental activities and take a leadership role in biotechnology R&D applications within the electricity enterprise. Technologies related to bioenergy crops, bioremediation, phytoremediation, and biocatalysts development should all produce positive short-term benefits for the electricity enterprise. On the other hand, biological removal of metals from fuel, biohydrogen, and biocorrosion control should be considered long-term R&D activities. The report also identifies biotechnology areas where EPRI's Office of Technology Innovation (TI) can take an active role in R&D activities, including periodic horizon scanning of biotechnologies, comparison of the application of bio- and conventional technologies for using solar energy to deliver useful electricity, and development of a biomass technology assessment guide. In all, this report emphasizes that EPRI needs to be in the forefront of R&D and demonstration activities in the biotechnology arena, as applied to the electricity enterprise. For more information, contact John W. Goodrich-Mahoney, (202) 293-7516, [jmahoney@epri.com](mailto:jmahoney@epri.com).

### ***Second Workshop on Managing FGD Wastewater Scheduled for October***

As a follow-up to last year's workshop in Atlanta, a second workshop on the impact of FGDs on wastewater will be held at the Drury Hotel, #2 South Fourth Street, St. Louis, MO from 1 p.m. on Oct. 29 to noon on Oct. 30. The objectives are to hear the latest on EPRI FGD wastewater R&D, to provide members an opportunity to share operating experiences and issues, and to identify common data needs that should be addressed. Members are encouraged to present their perspectives and the operating experience of their FGD wastewater treatment system(s). There is no charge to attend the workshop for members of Program 56 (Effluent Guidelines and Water Quality Management) or Program 75 (Integrated Environmental Controls). This meeting will be followed directly by meetings of the SO<sub>2</sub> Control Interest Group (SOCIG) on the afternoon of Oct. 30 and the Aerosol Control Interest Group (AECIG) on the morning of Oct. 31. For more information or to make a presentation at the FGD wastewater meeting, please contact Paul Chu, (650) 855-2812, [pchu@epri.com](mailto:pchu@epri.com), or Chuck Dene, (650) 855-2425, [cdene@epri.com](mailto:cdene@epri.com).

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## **T&D ENVIRONMENTAL ISSUES**

## **Program 51: T&D Facilities & Equipment: Environmental Issues**

### ***Arsenic Working Group and Sandia National Laboratories Plan Joint Workshop***

The November 29 meeting of the Arsenic Working Group in Dallas, TX will be a workshop held jointly with Sandia National Laboratories (SNL). SNL has a vigorous program in arsenic studies, including work in both soil and water remediation. Workshop participants will hear about novel approaches to removing arsenic from water under development at SNL, which is a member of the Arsenic Water Technology Partnership funded through the U.S. Department of Energy. The Partnership is a \$13 million, multi-year effort to accelerate the development of innovative arsenic treatment technologies from bench-scale to pilot-scale demonstration. In

2004–2006, SNL conducted pilot-scale demonstrations of a wide range of alternative technologies under differing conditions at six arsenic-contaminated sites; [results](#) are available online. EPRI sponsored research using hybrid ion exchange, phytoremediation, and *in situ* chemical fixation will also be discussed at the workshop. For more information, contact Mary McLearn, (650) 855-2487, [mmclearn@epri.com](mailto:mmclearn@epri.com). *Note:* See [related arsenic articles under Program 42 or 53](#).

### ***In Situ Chemical Fixation Prevents Arsenic Leaching from Contaminated Soil***

[In Situ Chemical Fixation of Arsenic-Contaminated Soil](#) (1014056). In long-term laboratory column studies, no detectable arsenic leached from contaminated soils treated with the chemical fixation reagents ferrous sulfate (FS) or ferrous sulfate plus lanthanum chloride (FSLA), even after 280 years of simulated leaching by natural precipitation. This is good news for electric power companies that own sites contaminated by past use of arsenic herbicides, pesticides, and wood preservatives. At sites where source removal is too costly or infeasible because a facility is energized, *in situ* chemical fixation (ISCF) can provide a viable answer to the need for soil treatment because it binds arsenic in place. In this 3-year study, researchers identified three candidate reagents through a literature review, and conducted laboratory batch and column treatability studies on five characterized soil samples using the reagents. FS and FSLA performed well in binding arsenic; a proprietary reagent, Metals Remediation Compound®, did not. To foster regulatory acceptance of the technology, EPRI plans field trials to demonstrate the permanence of ISCF with appropriate application. For instance, FS and FSLA produce stable results under oxidizing subsurface conditions but their performance needs to be tested under reducing conditions. For more information, contact Mary McLearn, (650) 855-2487, [mmclearn@epri.com](mailto:mmclearn@epri.com). *Note:* See [related arsenic articles under Program 42 or 53](#).

### **Program 60: EMF Health Assessment and RF Safety**

[Visit the EMF Health Assessment and RF Safety Public Webpage](#)

#### ***EPRI Comments on a Study of Occupational Magnetic Field Exposure and Alzheimer's Disease***

Davanipour Z, et al. "A case-control study of occupational magnetic field exposure and Alzheimer's disease: results from the California Alzheimer's Disease Diagnosis and Treatment Centers." *BMC Neurology*, 9 June 2007, 7:13. This case-control study examines the possible association between occupational magnetic field exposure and Alzheimer's disease (AD) among patients residing in eight California Alzheimer's Disease Diagnosis and Treatment Centers located throughout the state. Cases were 1502 patients, over the age of 65 at first examination, who were diagnosed with probable or definite AD. Controls were 396 similar patients whose dementia was not related to AD or vascular causes. Subjects were assigned to magnetic field exposure categories based on their reported primary occupations by one investigator using his expert judgment. Thirty-two (2.1%) cases and 3 (0.8%) controls had high exposure (average individual exposure > 1  $\mu$ T or regular intermittent exposures > 10  $\mu$ T), while 81 (5.4%) cases and 12 (3.0%) controls had medium exposure (average individual exposure 0.2–1.0  $\mu$ T or regular intermittent exposures > 1  $\mu$ T). High-exposure occupations included garment workers, pilots, and welders. Logistic regression analyses showed significant risk factors for AD, including magnetic field exposure, gender, stroke, and age. Combining results from this study with those of two previous studies by the same authors yielded an odds ratio of 3.7 ( $p < 0.001$ ) for sewing machine operators. The authors conclude that, "Elevated occupational MF [magnetic field] exposure was associated with an increased risk of AD . . . Sewing machine operators . . . are likely to be at increased risk of developing AD, for some reason. It is important to confirm this statement with targeted studies and, if confirmed, to determine the etiologically relevant exposure(s)."

EPRI suggests caution in interpreting the authors' conclusions. Since no information was available on the length of employment in primary occupations and occupational histories may have been obtained by interviews with proxies, significant exposure misclassification may have occurred. Increased risk for AD observed among sewing machine operators could be linked to other exposures in their work environment and not necessarily to magnetic field exposure. Small numbers of controls in the high- and medium-exposure categories (3 and 12, respectively) make risk estimates quite unstable. Finally, the authors' overall conclusion appears to be more in favor of an association than conclusions reached in recent publications, including an *Environmental Health Criteria* monograph on extremely low frequency (ELF) electric and magnetic fields (EMF) by the World Health Organization (WHO) and a consensus report from an Edinburgh, Scotland workshop on occupational ELF EMF epidemiology, soon to be a submitted manuscript. According to the workshop report, "although studies of EMF

and AD have been fraught with methodological difficulties and have yielded inconsistent results, there is some suggestion for an association.” Both the workshop report and the WHO monograph call for further research. These comments ([1015351](#)) are available to Program 60 members on epri.com. For more information, contact Gabor Mezei, (650) 855-8908, [gmezei@epri.com](mailto:gmezei@epri.com).

### ***The BioInitiative Working Group Report***

A report assessing research on the potential health effects of exposure to electric and magnetic fields (EMF) was recently issued by the BioInitiative Working Group. This group, consisting mainly of EMF scientists, was convened on an ad hoc basis to conduct an independent examination of EMF health risk. The group was not convened under the imprimatur of a governmental body, professional society, or recognized risk assessment organization, such as the International Agency for Research on Cancer (IARC). The group’s report, [BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields \(ELF and RF\)](#), was coedited by Dr. David Carpenter, Director of the Institute for Health and the Environment at the University at Albany in New York, and Ms. Cindy Sage, who has been involved with EMF and power line siting issues. Dr. Carpenter and Ms. Sage are responsible for a section of the report that summarizes the scientific evidence and for making recommendations based on this summary.

The BioInitiative Report covers both the extremely low frequency (ELF) EMF associated with electric power and radio-frequency (RF) EMF from sources such as cellular telephones and RF transmitters. Its main conclusion is that limits for public EMF exposure set by organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE) are inadequate to protect health and require substantial reduction. For ELF magnetic fields, the report recommends a more than 800-fold reduction of the ICNIRP limit and a 9,000-fold reduction of the IEEE limit. For RF fields, a 2,000-fold reduction is recommended.

The current ICNIRP limit for public ELF EMF exposure at power frequency in the United States is 0.83 Gauss (0.083 millitesla), and the IEEE limit is 9.1 Gauss (0.91 millitesla). The limits for ELF magnetic fields recommended in the BioInitiative Report “while new ELF limits are being developed and implemented” are 1 milligauss (0.1 microtesla) for “habitable space adjacent to all new or upgraded power lines” and 2 milligauss (0.2 microtesla) for all other new construction. The report also recommends a 1-milligauss limit for “existing habitable space for children and/or women who are pregnant.” The recommended limit for outdoor RF exposure is  $0.1 \mu\text{W}/\text{cm}^2$ .

EPRI notes that, unlike the expert panels that conducted previous EMF health risk evaluations for IARC, the U.S. National Institute of Environmental Health Sciences (NIEHS), and the World Health Organization (WHO), the BioInitiative Working Group was not convened by any governmental bodies or recognized health risk assessment organizations. Moreover, its conclusions, opinions, and recommendations are not consistent with those reached by previous panels.

All previous assessments recognize the association found in epidemiologic studies between residential ELF magnetic fields and childhood leukemia and the unexplained nature of this association. When all EMF health studies are considered together, the risk of leukemia for children with average residential magnetic fields above 3 to 4 milligauss (0.3 to 0.4 microtesla) is about 1.7 to 2.0 times the risk of children in residences with lower fields. For such weak epidemiologic associations, supporting data from laboratory studies are usually critical for establishing a causal link. Long-term studies of ELF magnetic field exposure in rodents are consistently negative, and there is no biophysically plausible basis for a causal relationship. Nevertheless, the BioInitiative Working Group concluded that “up to 80% of childhood leukemia may be caused by exposure to ELF,” an estimate that is unsubstantiated. Moreover, the 1-milligauss limit the working group calls for would produce a dose in the body between 200 and 2,000 times less than the lowest dose levels expert panels believe could cause biological effects. Studies of RF exposure and cancer in rodents have also been negative, and the BioInitiative Report’s recommended limits for RF exposure would produce a very small deposition of energy in the body.

Unlike the BioInitiative Report, previous EMF health risk assessments that have made recommendations regarding precautionary measures (for example, a 1999 NIEHS report and a 2007 WHO assessment) have supported measures that are safe and cost-effective. For example, WHO recommends implementation of low-cost measures in the design and engineering of new facilities, devices, and equipment, including appliances.

The BioInitiative Report will likely be subject to further scrutiny and review by the scientific community. Despite the report's position, the scientific community has determined that the ICNIRP and IEEE guidelines are protective against the known effects of ELF and RF exposures. The ICNIRP and IEEE exposure limits for ELF magnetic fields are designed to prevent nerve stimulation caused by electric fields induced in the body. As WHO stated in its June 2007 *Environmental Health Criteria* document with respect to acute neural stimulation effects of EMF exposure, "International guidelines exist that have addressed this issue. Compliance with these guidelines provides adequate protection." RF exposure limits, such as those published by the Federal Communications Commission (FCC), ICNIRP, and IEEE are designed to protect against tissue heating from deposition of thermal energy in the body. WHO plans to review the RF literature in coming years.

EPRI's EMF Health Assessment and RF Safety program continues to conduct research to investigate the uncertainties surrounding the association of magnetic fields with childhood leukemia and to address priority issues related to RF exposure, dosimetry, and safety practices. For more information, contact Rob Kavet, (650) 855-1061, [rkavet@epri.com](mailto:rkavet@epri.com).

### ***National Academy of Sciences Workshop on Radiofrequency Research Needs***

Guidance on future radiofrequency (RF) research needs was the subject of a workshop held August 7–9 in Washington, DC. The workshop engaged national and international experts who are members of a committee convened by the National Academy of Sciences at the request of the Food and Drug Administration. The committee mandate was to identify gaps in knowledge of biological effects and possible adverse health outcomes of exposure to RF energy from wireless communications devices. With the explosion of wireless technology and frequent news stories about RF health research, concerns of employees and the public must be addressed. The workshop featured more than two days of public presentations by RF researchers followed by question-and-answer periods, as well as closed committee discussions. Topics covered included RF exposure and dosimetry, epidemiology, human laboratory research, mechanisms, animal and cell biology, and overarching issues and research needs. Workshop participants noted that RF research is currently where ELF research was 15–20 years ago. In 2008, the committee will issue a research guidance report based on workshop recommendations. Dr. Leeka Kheifets, now an EPRI research consultant, is a member of the committee. For more information, contact Mike Silva, (650) 855-2815, [msilva@epri.com](mailto:msilva@epri.com).

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## **ENVIRONMENT FEDERAL HIGHLIGHTS (Washington D.C. Office, John Novak)**

### ***Senate Hearings on Advanced Coal Technologies and CO<sub>2</sub> Capture and Storage***

On August 1, Jeff Phillips of EPRI testified at a hearing on the, "Status of Advanced Coal Technologies and RD&D Needs to Enable Readiness for Commercial Application", before the U.S. Senate Committee on Energy and Natural Resources. Jeff testified that with the development and deployment of advanced coal technologies with CO<sub>2</sub> capture and storage (CCS) technologies, coal power becomes part of the solution to satisfying both our energy needs and our global climate change concerns. Jeff referenced EPRI's "Electricity Technology in a Carbon-Constrained Future" study (also referred to as the PRISM analysis) that suggests that it is technically feasible to reduce U.S. electric sector CO<sub>2</sub> emissions over the next 25 years while meeting the increased demand for electricity and that the largest single contributor to emissions reduction would come from the integration of CCS technologies to advanced coal-based power plants coming on-line after 2020. Economic analyses of scenarios to achieve the study's emission reduction goals show that a 2030 U.S. energy mix including advanced coal technologies with integrated CCS results in electricity at a much lower cost than a 2030 energy mix without advanced coal with CCS. He pointed out that a sustained RD&D program at heightened levels of investment and resolution of legal and regulatory unknowns for long-term geologic CO<sub>2</sub> storage will be required to achieve the promise of clean coal technologies. Jeff's testimony provided details on the RD&D program and funding developed under EPRI's *CoalFleet for Tomorrow*<sup>®</sup> program. On August 13,

Jeff Phillips testified on the same topic at a field hearing of the U.S. Senate Appropriations Subcommittee on Energy and Water Development in Bismarck, ND.

### ***Meeting with Senator Bingaman***

On August 20, Senator Jeff Bingaman (D-NM) and several of his staff met with representatives of EPRI at EPRI's office in Palo Alto. In his position as Chairman of the Senate Energy and Natural Resources Committee, the Senator is interested in promoting RD&D on technologies to allow the U.S. to meet future energy needs while addressing environmental concerns, such as global climate change. The purpose of the visit was for the Senator and his staff to obtain information on EPRI's research and analysis related to energy efficiency, electricity generation, and global climate change. Representatives from each of the EPRI sectors provided overviews of pertinent EPRI research. Bryan Hannegan provided an overview of the PRISM/MERGE analysis on technology and global climate change.

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## **Environment Sector Supplemental Projects**

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### **Air Quality**

#### ***Program 42: Air Toxics Health and Risk Assessment***

- "Global Pollutant Challenge." For more information, contact Leonard Levin, (650) 855-7929, [llevin@epri.com](mailto:llevin@epri.com).
- [Health Research to Inform the Revision of the Arsenic Cancer Potency Factor](#)
- [Measurement of Mercury in Power Plant Plumes: An Intensive Field Study](#)
- "MercSyn—The Mercury Synoptics Experiment." For more information, contact Leonard Levin, (650) 855-7929, [llevin@epri.com](mailto:llevin@epri.com).
- [Mercury Experiment to Assess Atmospheric Loading in Canada and the United States \(METAALICUS\): Phase II, Evaluating the Effects of Loadings](#)

#### ***Program 91: Assessment Tools for Ozone, Particulate Matter, and Haze***

- [Secondary Particulate Health Effects Research \(SPHERES\): Exploring the Influence of SO<sub>2</sub>, NO<sub>x</sub> and Acids on the Chemistry and Health Effects of PM-2.5](#)
- [Regional PM Characterization to Enable Source-Receptor Modeling: Data Collection](#)
- [Theoretical, Experimental, and Ambient Studies of Particulate Oligomers and Organic-Nitrogen Species \(TEASPOONS\): A Health Impact Perspective](#)

#### ***Program 92: Assessment of Air Quality Impacts on Health and the Environment***

- [Secondary Particulate Health Effects Research \(SPHERES\): Exploring the Influence of SO<sub>2</sub>, NO<sub>x</sub> and Acids on the Chemistry and Health Effects of PM-2.5](#)
- [Integrated Chamber and Panel Study \(ICAPS\)](#)
- [Tri-City Concentrated Ambient Particle Study \(Tri-City CAPS\)](#)
- [Children's Air Pollution Asthma Study: Part of the ARIES Program](#)
- [Detroit Cardiovascular Health Study](#)
- [Health Effects of Air Pollution and Particulate Matter Components: Texas ARIES](#)
- [Reanalysis of Key PM-Health Dataset](#)
- [Sources and Composition of Particulate Exposures \(SCOPE\) Study](#)
- [Toxicological Evaluation of Realistic Emissions of Source Aerosols \(TERESA\)](#)

### **Global Climate Change**

#### ***Program 102: Global Climate Policy Costs and Benefits***

- [Developing GHG Emissions Offsets by Reducing Nitrous Oxide \(N<sub>2</sub>O\) Emissions in Agricultural Crop Production](#)
- [Enhanced Assessment of Costs and Benefits of Climate Policy Proposals](#)







