# TECHNICAL SUPPORT DOCUMENT
# FOR
# REDUCING MERCURY EMISSIONS FROM
# COAL-FIRED ELECTRIC GENERATING UNITS

**AQPSTR 06-02**

**MARCH 14, 2006**

**AIR QUALITY PLANNING SECTION**
**DIVISION OF AIR POLLUTION CONTROL**
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**ILLINOIS ENVIRONMENTAL PROTECTION AGENCY**
**SPRINGFIELD, IL**

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## List of Acronyms Used

| | |
|---|---|
| ACFM | actual cubic feet per minute |
| ADL | Activities of Daily Living |
| ADL | Above Detection Limits |
| AEA | Air Entrainment Admixture |
| AMI | Acute Myocardial Infarction |
| APC | Air Pollution Control |
| ARP | Acid Rain Program |
| ATSDR | Agency for Toxic Substance and Disease Registry |
| BDL | Below Detection Limits |
| BMD | Bench Mark Dose |
| BMDL | Bench Mark Dose Limit |
| BMP | Best Management Practices |
| BMR | Bench Mark Response |
| BNT | Boston Naming Test |
| BSID | Bayley Scales of Infant Development |
| Btu | British Thermal Unit |
| CAA | Clean Air Act |
| CAIR | Clean Air Interstate Rule |
| CAMR | Clean Air Mercury Rule |
| CEC | Commission for Environmental Cooperation |
| CHD | Coronary Heart Disease |
| CO2 | Carbon Dioxide |
| CPT | Continuous Performance Test |
| CS-ESP | Cold-side Electrostatic Precipitator |
| CSO | Combined Sewer Overflows |
| CV | Cardiovascular |
| CVLT | California Verbal Learning Test |
| CWA | Clean Water Act |
| DDST | Denver Developmental Screening Test |
| DOE | U.S. Department of Energy |
| DOE/NETL | DOE National Energy Technology Laboratory |
| DRH | Differential Reinforcement of Higher Rates of Behavior |
| ECO | Electro-Catalytic Oxidation |
| ECOS | Environmental Council of States |
| EG | Emissions Guidelines |
| eGrid | Emissions and Generation Resource Integrated Database |
| EGU | Electrical Generating Unit |

| | |
|---|---|
| EIA | Energy Information Administration |
| ESP | Electrostatic Precipitator |
| FERC | Federal Energy Regulatory Commission |
| FF | Fabric Filter |
| FGD | Flue Gas Desulphurization Scrubber |
| FI | Fixed Interval |
| GW | Gigawatt |
| GWh or GWhr | Gigawatt Hour |
| Hg | Mercury |
| Hg(II) | Oxidized Gaseous Mercury |
| Hg(p) | Particulate Mercury |
| Hg0 | Elemental Mercury |
| HPV | Health Protection Value |
| HS-ESP | Hot-side Electrostatic Precipitator |
| ICAC | Institute of Clean Air Companies |
| ICC | Illinois Commerce Commission |
| ICR | Information Collection Request |
| IFCMP | Illinois Fish Contaminant Monitoring Program |
| Illinois EPA | Illinois Environmental Protection Agency |
| IPM | Integrated Planning Model |
| JBR | Jet Bubbling Reactor |
| kg | Kilogram |
| KW | Kilowatt |
| L | Liter |
| LADCO | Lake Michigan Air Directors Consortium |
| lb | Pound |
| LDL | Low Density Lipids |
| LMB | Largemouth Bass |
| LSFO | Limestone Forced Oxidation |
| LSNO | Limestone Natural Oxidation |
| MACT | Maximum Achievable Control Technology |
| MAIN | Mid-America Interconnected Network |
| MEL | Magnesium Enhanced Lime |
| mg | Milligram |
| MI | Myocardial Infarction |
| mills | Millidollars |
| MISO | Midwest Independent System Operator |
| MMacf | million actual cubic feet |
| MOA | Memorandum of Agreement |

| | |
|---|---|
| MR | Mental Retardation |
| MW | Megawatt |
| MWC | Municipal Waste Combustors |
| MWh or MWhr | Megawatt Hour |
| NAS | National Academy of Sciences |
| NEI | National Emissions Inventory |
| NESCAUM | Northeast States for Coordinated Air Use Management |
| NHANES | National Health and Nutrition Examination Survey |
| NIEHS | National Institute of Environmental Health Sciences |
| NOAEL | No Observed Adverse Effect Level |
| NOx | Nitrogen Oxides |
| NPDES | National Pollutant Discharge Elimination System |
| NRC | National Research Council |
| NSPS | New Source Performance Standards |
| NWF | Nation Wildlife Federation |
| NYSY | National Longitudinal Survey of Youth |
| OR | Odds Ratio |
| ORD | USEPA Office of Research and Development |
| OSHA | Occupation Safety and Health Administration |
| oz. | Ounce |
| PAC | Powdered Activated Carbon |
| PB | Physiologically Based |
| PBrDD | Polybromininated dibenzo-*p*-dioxin |
| PBrDF | Polybrominated dibenzofuran |
| PCB | Polychlorinated Biphenyls |
| PCDD | Polychlorinated dibenzo-*p*-dioxin |
| PCDF | Polychlorinated dibenzofuran |
| PCS | Permit Compliance System |
| PK | Pharmacokinetic |
| Plan | State Implementation Plan |
| PM | Particulate Matter |
| ppm | parts per million |
| ppt | parts per trillion |
| PRB | Powder River Basin |
| PS | Particulate Scrubber |
| QALY | Quality Adjusted Life Years |
| RfD | Referenced Dose |
| RGM | Reactive Gaseous Mercury |
| ROFA | Rotating Over-fired Air |

| | |
|---|---|
| ROM | Run of Mine |
| ROS | Reactive Oxygen Species |
| RR | Relative Risk |
| RTO | Region Transmission Organizations |
| SCR | Selective Catalytic Reduction |
| SDA | Spray Dryer Absorber |
| SI | Sorbent Injection |
| SIP | State Implementation Plan |
| SO2 | Sulfur Dioxide |
| SO3 | Sulfur Trioxide |
| Tbtu | Trillion British Thermal Units |
| TMDL | Total Maximum Daily Load |
| TOLD_SL | Test of Language Development Spoken Language Quotient |
| TSD | Technical Support Document |
| TTBS | Temporary Technology Based Standard |
| TWh or TWhr | Terawatt Hour |
| UBC | Unburned Carbon |
| UF | Uncertainty Factor |
| ug | Microgram |
| USEPA | United States Environmental Protection Agency |
| WHO | World Health Organization |
| WISC-R | Wechsler Intelligence Scale for Children Revised |

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## Executive Summary

Introduction

On January 5, 2006, Illinois Governor Rod R. Blagojevich announced an aggressive proposal to reduce mercury emissions from Illinois coal-fired power plants by 90 percent beginning mid 2009. The Governor's proposal is intended to require coal-fired power plants in Illinois to achieve greater reductions of mercury more quickly than that proposed by the United States Environmental Protection Agency (U.S. EPA) under the federal Clean Air Mercury Rule (CAMR) in May 2005. Mercury is a persistent, bioaccumulative neurotoxin that presents a serious threat to the health and welfare of the citizens of Illinois and nationwide. The Governor's proposal would achieve the largest reductions of mercury emissions from coal-fired power plants of any state in the country. Other states have made similar decisions. Five states have adopted mercury reduction programs that "go beyond" CAMR in their reduction target or timeframe for obtaining reductions, and a number of other states have announced their intentions to do so as well.

Fate of Mercury in the Environment and Health Impacts of Mercury

Mercury is both a naturally occurring trace element found in the environment, and a pollutant that is released to the environment by human (anthropogenic) activities, including the combustion of coal to produce electricity. The combustion of coal at power plants represents the largest source category of mercury emissions in the U.S.

Mercury is a persistent, bioaccumaulative neurotoxin. Unborn children, infants and young children are at greatest risk from mercury. Fetal exposure to excessive levels of mercury has been linked to mental retardation, cerebral palsy, lower IQ, slowed motor function, deafness, blindness and other health problems. Recent studies indicate that as many as 10 percent of children born in the United States have been exposed to excessive levels of mercury in the womb. Because of the risk mercury poses to unborn children and infants, mercury exposure is of concern for pregnant women and women of childbearing age who may become pregnant.

Regulatory Background

Mercury is listed as a Hazardous Air Pollutant (HAP) under Section 112(b) of the federal Clean Air Act. Section 112 requires the U.S. EPA to establish Maximum Achievable Control Technology (MACT) standards for both new and existing source categories that are major emitters of HAPs. The stringent system of emissions controls encompassed under the MACT provisions is intended to ensure control technology is used to minimize emissions of HAPs from the major emitters.

Under Section 112(n) of the CAA, U.S. EPA was directed to conduct a study of electric utility boilers to assess the hazards to public health from their emissions of HAPs, and submit it to Congress. U.S. EPA submitted the study to Congress in 1998, referred to as the "*Mercury Study Report to Congress*" (December 1997).

Based on the Mercury Study, on December 20, 2000, U.S. EPA issued a finding under Section 112(n) that it was appropriate and necessary to regulate coal and oil-fired utility boilers under Section 112 (Regulatory Finding). U.S. EPA concluded that this affirmative determination under Section 112(n) constituted a decision to list coal and oil-fired power plants on the Section 112(c) source category list, thereby requiring it to develop a MACT standard for HAP emissions from those sources.

On January 30, 2004, U.S. EPA published a notice of proposed rulemaking setting forth three alternative regulatory approaches to reducing emissions of mercury from coal-fired power plants. In two of the three alternatives, U.S. EPA proposed to rescind its Regulatory Finding, which would require MACT-level control of mercury emissions, and instead imposed state-wide mercury emissions budgets to regulate power plants that could be met through a cap and trade program.

In response to the proposed rules, the Illinois EPA submitted comments on these proposed alternatives, making the following key points:

- Mercury is a powerful neurotoxin that needs to be regulated under Section 112(d) of the Clean Air Act (CAA), and as such, the mercury emissions from the power plants must be subject to a MACT standard;

- The mercury limits must be more stringent than set forth in the proposed rule;

- Any mercury rule for power plants must be fuel neutral, without favoring coal from any particular region of the country, and thus there should be a common standard for bituminous and subbituminous coal;R

- Illinois EPA opposes emissions trading of mercury allowances unless the units involved in a trading can demonstrate that mercury hot spots are prevented; and

- Mercury emission reductions can and should occur by 2010.

The comments also stated that U.S. EPA gave insufficient support for its extended compliance deadline of 2018, which U.S. EPA acknowledged could extend compliance out to 2025 or 2030 due to banking elements of the trading program.

Despite receiving an enormous number of negative comments on its proposal, and over five years after U.S. EPA issued its Regulatory Finding, U. S. EPA published the CAMR on May 18, 2005. Notably, CAMR did not apply a MACT standard to mercury and other HAP emissions from coal-fired power plants, and instead established "standards of performance" limiting mercury emissions from new and existing coal-fired power plants and created a market-based cap-and-trade program to reduce nationwide power plant emissions of mercury in two separate phases. The first phase cap is 38 tons and was set by determining the level of mercury reductions achieved as a "co-benefit" of requirements for reducing sulfur dioxide ($SO_2$) and nitrogen oxides (NOx) emissions under the federal Clean Air Interstate Rule (CAIR). In the second phase, due in 2018, coal-fired power plants will be subject to a second cap, which will limit emissions to 15 tons upon full implementation. Illinois' budget under CAMR is 1.594 tons per year of mercury for Phase I and 0.629 tons per year for Phase II. This equates to a reduction in mercury emissions from Illinois coal-fired EGUs of approximately 47 percent by 2010 and 78 percent by 2018.

The Illinois EPA determined that CAMR will not result in sufficient reductions of mercury in a timely manner, and that CAMR will impede its efforts to encourage clean-coal technology that will allow Illinois' abundant coal reserves to be used in an environmentally responsible manner. Illinois EPA requested that the Illinois Attorney General's Office file an appeal of CAMR and the Delisting Action. On May 27, 2005, the State of Illinois filed Petitions for Review with the United States Court of Appeals for the District of Columbia Circuit challenging both rules. Thirteen other states also filed one or more appeals of the CAMR and the Delisting Action. These appeals are pending.

Other Programs to Control Mercury in the Environment

Because mercury is of such a significant concern to human health and the environment, Illinois has adopted legislation and/or implemented a number of programs to reduce mercury emissions to the environment from sources other than coal-fired power plants. These programs, as well as pending legislation, include the following:

- Prohibitions on the sale of mercury electrical switches and relays in consumer and commercial products, and restrictions on the use of elemental mercury and mercury-containing scientific equipment in K-12 schools;

- A bill is pending before the general assembly to require automakers to create a statewide program to collect and recycle mercury switches from discarded or end-of-life vehicles before they are processed as scrap metal, and if capture rate targets are not met, the auto recyclers and scrap metal processors would collect a $2 bounty for each switch removed;

- A program to help K-12 schools properly dispose of waste chemicals used for teaching purposes, including bulk mercury and mercury-containing devices;

- Collection of mercury containing products as part of the Household Hazardous Waste Collections;

- Teaming up with the Illinois State Dental Society to arrange for mercury and mercury amalgams to be disposed of in an environmentally friendly manner at the household hazardous waste collections;

- Promotion of the National Thermostat Recycling Corporation's thermostat collection program to Heating, Ventilation, and Air Conditioning contractors in the state through direct mailings and other educational outreach activities;

- Adoption of regulations addressing emissions of hazardous pollutants, including mercury, from the combustion of hospital and medical/infectious wastes, which resulted in the shut down of all but 12 of the 98 affected incinerators at hospitals; and;

- Governor Blagojevich's continuing initiative to require all hospital waste incinerators to shut down and find other waste disposal options.

Illinois Coal-Fired Power Plants

Today, around 40% of Illinois' electricity comes from coal-fired power plants. Illinois is home to 21 coal-fired power plants, most of which are over 25 years old. These coal-fired power plants constitute the largest source of uncontrolled mercury emissions in the State, emitting an estimated 3.85 tons per year of mercury into the atmosphere. The State's fleet of power plants are scattered throughout Illinois, with many located near major bodies of water.

Proposed Illinois Mercury Rule

The proposed Illinois mercury rule is designed to achieve a high level of mercury control, based on Illinois EPA's finding that there exists mercury control technology that is both technically feasible and economically reasonable.

Briefly, the proposed rule requires mercury reductions from Illinois' coal-fired power plants in two phases. During phase I, which begins on July 1, 2009, coal-fired power plants must comply with either an output-based emission standard of 0.0080 lbs mercury/GWh, or a minimum 90-percent capture of inlet mercury, both on a rolling 12-month basis. However, plants with the same owner/operator may elect to comply with the limit on a system-wide basis by averaging across their entire fleet of plants in Illinois, provided that each plant meets a minimum output-based emission standard of 0.020 lbs mercury/GWh or a minimum 75-percent capture of inlet mercury. In Phase II, beginning January 1, 2013, plants must comply with either of an output-based emission standard of 0.0080 lbs mercury/GWh or a minimum 90-percent capture of inlet mercury, both on a rolling 12-month basis. The proposed rule ensures that reductions occur both in Illinois and at every power plant in Illinois in order to address local impacts. The rule does not allow for the trading, purchasing or the banking of allowances.

The Impacts of the Proposed Illinois Mercury Rule

The fleet of coal-fired power plants in Illinois will be the largest in the nation to be subject to stringent mercury reduction requirements. The mercury reductions obtained from Illinois' proposed rule will be beyond those of the federal CAMR and will occur more quickly. Whereas CAMR would cap Illinois' annual mercury emissions at 3,188 pounds by 2010, the proposed Illinois rule results in annual mercury emissions of only around 770 pounds beginning mid-2009. Therefore, the proposed rule should eliminate approximately 2,418 additional pounds per year of harmful mercury pollution, and do so six months earlier than the federal CAMR. The reductions obtained under the proposed Illinois rule will likewise be greater than those required in Phase II of CAMR, which does not go into effect until 2018. The CAMR budget for Illinois in Phase II is 1,258 pounds per year, but with banking allowed under CAMR, it is not expected that actual emission reductions will occur until 2020 or later. Compared to CAMR, the proposed Illinois rule should result in an estimated 488 fewer pounds of mercury emissions per year about seven years sooner. It is important to note that CAMR is a cap and trade program and therefore, under CAMR, Illinois power plants could postpone or avoid some mercury reductions through the purchase or banking of allowances, an option not allowed under Illinois' proposed rule.

Section 8 of the document provides a detailed review of the current and developing mercury control technologies and the control effectiveness that can be achieved from these technologies. Mercury emissions may be reduced through the application of control technology specifically designed to control mercury (e.g., sorbent injection), or through co-benefit from other control techno logies designed to control $SO_2$, NOx, and particulate matter (e.g., flue gas desulfurization, selective non-catalytic or selective catalytic reduction, fabric filters, electrostatic precipitators). Depending on several variables, including coal and boiler type, there are a number of control technologies that will achieve 90+% removal of mercury. Mercury emissions control technology is a rapidly advancing field, with use of halogenated sorbents being an affordable and effective option for many applications. Although there may be some challenges to achieving 90% removal of mercury, each of these challenges can be overcome or addressed through technology that is economically reasonable and available today.

In addition to the detailed mercury control and cost analysis performed in Section 8 of this document by Illinois' technical expert, Dr. James Staudt, Illinois utilized the services of ICF Resources Incorporated (ICF) to evaluate the economic impact of the proposed rule on Illinois' electricity rates and affected power plants. ICF used the Integrated Planning Model (IPM) to evaluate these costs. While there are some additional costs predicted from the proposed rule when compared to CAMR, the costs are deemed to be reasonable in light of the concerns presented by mercury pollution.

Over time, Illinois expects to see reductions in mercury water deposition to Illinois' lakes and streams and corresponding methylmercury decreases in Illinois fish tissues, making fish caught in Illinois waters safer to eat. Our review of fish consumption literature discussed in Section 5 of this document provides convincing evidence that sport anglers currently consume amounts of sport-caught fish that could cause them and their families to exceed health-based limits for mercury contamination. The literature regarding anglers' consumption of their catch strongly suggests that a subset of these anglers have meal frequencies that exceed the state-wide fish consumption advisory for mercury, putting them well above the recommended rates for even fairly low levels of contamination.

There will be several recognized benefits to the State from tighter mercury controls beyond the expected public health benefits that come with a reduction in water and fish methylmercury levels. Such benefits include support for existing and the potential for additional jobs resulting from the installation and operating requirements for additional pollution control devices. There also exists a potential for an increase in tourism and recreational fishing as mercury levels drop in fish, bringing an associated positive impact to local economies and the State overall. With the predicted increase in the use of bituminous coal, there should be a positive economic impact on the Illinois coal industry and Illinois coal mining jobs.

## 1.0 Introduction

This technical support document (TSD) provides the bases for the Illinois Environmental Protection Agency's proposed mercury emissions standards for Illinois' coal-fired electric generating units (EGUs). Coal-fired EGUs represent the largest unregulated source of mercury emissions in the State. On January 30, 2004, U.S. EPA proposed rules for regulating mercury emissions from coal-fired EGUs (69 *Fed. Reg.* 4652). U.S. EPA proposed two options for controlling mercury emissions either through a control technology standard with emissions limits or a cap-and-trade approach. On May 18, 2005, the Clean Air Mercury Rule (CAMR) was published in the *Federal Register* (70 *Fed. Reg.* 28606). The CAMR finalized standards for new sources that are less stringent than were proposed in January 2004, and finalized a cap-and-trade rule for EGUs.

Illinois, and several other states including New Jersey, California, Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Mexico, New York, Pennsylvania, Rhode Island, Vermont and Wisconsin disagreed with U.S. EPA, and challenged CAMR in federal actions. Illinois EPA believes that coal-fired EGUs should be regulated under Section 112 of the CAA to protect public health. Illinois EPA also believes that control technology, in addition to various optimization processes as explained in Section 8.0 of this TSD, is available to coal-fired power plants in order to achieve the reduction of mercury emissions at the proposed levels.

This TSD explains the rationale behind Illinois' proposal and is organized in the following manner: Section 2.0 of this TSD provides a brief background on mercury, the toxic pollutant of concern that is the subject of various studies, including U.S. EPA's Mercury Study and Utility Air Toxics Study. Also discussed in this Section are the various sources of mercury emissions in the U.S. and the list of coal-fired electric generating units in Illinois.

The adverse health effects from mercury and methylmercury contamination, the major reason for developing this proposal, are explained in Section 3.0. An overview of past occurrences of mercury poisoning, adverse health effects and impacts of mercury and methylmercury exposure, and costs of environmental exposure to methylmercury are included in Section 3.0. This section is based in large part from the Michigan Mercury Report (Michigan's Mercury Electric Utility Workgroup, "Final Report on Mercury Emissions from Coal-Fired Power Plants," June 20, 2005) and the attached Appendix A of this TSD "Review of the Nervous system and Cardiovascular Effects of Methylmercury Exposure." Detailed discussions on neurotoxicity and cardiovascular effects, and societal costs associated with methylmercury exposure in the United States are found in Appendix A.

Section 4.0 gives a description of the state of mercury-impaired waters in the state, the impact of mercury releases to the Illinois aquatic systems and how human health-based concentrations of methylmercury in fish tissues tested in Illinois influence the current level of fish consumption advisories in the State.

Section 5.0 provides a detailed discussion on atmospheric deposition of mercury and analyses of recent source receptor modeling studies that relates atmospheric deposition of mercury to local emissions sources.

Section 6.0 of this TSD provides the format and rationale for the proposed Illinois standards for mercury emissions from Illinois' coal-fired electric generating units.

Section 7.0 gives an overview of the various mercury regulations in other states and on-going regulatory activities, at the federal and state levels, related to the reduction of mercury emissions from coal-fired EGUs. Also discussed in Section 7.0 are other programs in Illinois that prohibit or minimize mercury releases into the environment.

Section 8.0 of this TSD discusses the technical feasibility of mercury controls, specifically through sorbent injection. Also covered in this Section is an analysis of potential costs for Illinois EGUs to comply with the proposed mercury rule. Other discussions include coal cleaning, mercury control technologies currently available, and mercury removal co-benefits from conventional pollution control equipment typically installed on Illinois EGUs, e.g., cold-side electrostatic precipitators (CS-ESPs), hot-side electrostatic precipitators (HS-ESP), fabric filters (FF), wet and dry flue gas desulfurization (FGD) scrubbers, and nitrogen oxides ("NOx") control systems.

The results of Illinois' IPM modeling are discussed in Section 9.0 of this TSD.

Section 10.0 covers other relevant issues considered in the development of the proposed Illinois mercury standards.

Upon promulgation of the Clean Air Mercury Rule (CAMR) on May 18, 2005, Illinois is required to submit a state implementation plan ("SIP") that would address mercury emissions from coal-fired power plants under section 111 of the Clean Air Act. This TSD is in support of the Illinois SIP, addressing mercury emissions from coal-fired EGUs that is due for review and approval by U.S. EPA on November 17, 2006.

## 2.0 Background Information on Mercury

### 2.1 What is Mercury?

Mercury is a toxic heavy metal that is of significant concern as an environmental pollutant *(See: Agency for Toxic Substance and Disease Registry, Toxicological Profile: Mercury 1999, (ATSDR, 1999)(www.atsdr.cdc.gov/toxprofiles/tp46.html).* It exists in the environment naturally and as a product of man-made processes, including waste incineration and fossil fuel combustion. Mercury is a persistent environmental contaminant, which cannot be degraded or destroyed.

Mercury exists in two general forms in the environment: inorganic, which include elemental mercury, and organic forms. Elemental or metallic mercury is a heavy, silvery-white liquid metal at typical ambient temperature. Metallic mercury can readily vaporize into colorless and odorless vapors at room temperature. The higher the temperature, the more mercury vapors will be released to the environment.

When combined with carbon, mercury forms compounds referred to as organic mercury or "organomercurials." Inorganic mercury compounds are formed when mercury combines with other non-carbon elements such as chlorine, sulfur or oxygen. Three different forms of inorganic mercury emissions are typically modeled in atmospheric transport models. These are elemental ($Hg^0$), gas phase divalent mercury ($Hg^{2+}$) (also referred to as reactive gaseous mercury), and particulate-bound divalent mercury ($Hg_p$) *(See: "Economic Valuation of Human Health Benefits of Controlling Mercury Emissions from U.S. Coal-Fired Power Plants" Northeast States for Coordinated Air Use Management (NESCAUM, February 2005)(www.nescaum.org).* The reactive gaseous and particulate-bound forms of mercury are readily deposited to the surface of the earth through wet or dry deposition. (*See* Section 5.0 of this TSD for more discussions on atmospheric deposition modeling).

Mercury deposited into the aquatic systems transforms into methylmercury through microbial activity. Methylmercury is toxic and is the most common organic form of mercury found in the environment. It is very soluble and bioaccumulates within the tissues of wildlife (fish, aquatic invertebrates, mammals) as well as humans. (Mercury Study, 1997)

The Uility Air Toxics Study issued by U.S. EPA in February 1998 identified mercury as the hazardous air pollutant of "greatest potential concern" associated with coal-fired power plants.

## 2.2 Sources and Uses of Mercury

The Michigan Mercury Report (Michigan Electric Utility Workgroup, Final Report on Mercury Emissoins from Coal-Fired Power Plants," June 20, 2005) indicated that the toxicity and use of mercury has been known as far back as the early Roman Empire. Prisoners sent to work in cinnabar ore mines died from exposure to mercury vapors. In the 1800s, workers using mercury in manufacturing felt hats were poisoned and had physical symptoms that was referred to as "mad as a hatter."

Mercury is a mined commodity and is also produced as a by-product of gold and bauxite mining. Mercury is currently used in thousands of industrial, agricultural, medical and household applications due to its unique properties. Some examples of current mercury use include:

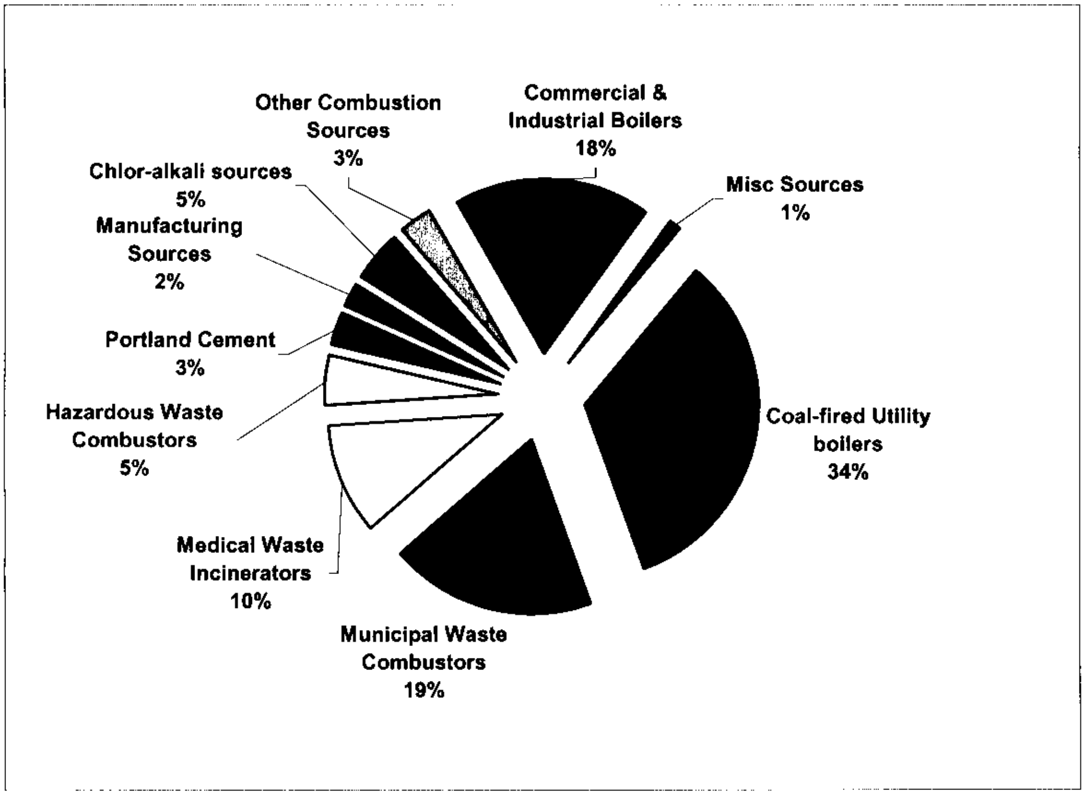
- Thermometers and sphygmomanometers
- Thermostats, barometers and manometers
- Relays and various switches (float switches in septic tanks, sump pumps and bilge pumps)
- Fluorescent and high intensity discharge lamps
- Preservative in vaccines

For a detailed tabulation of mercury sources and product usage, see Appendix D of the Michigan Mercury Report.

### 2.2.1 U.S. Anthropogenic Sources of Mercury Emissions

Mercury is a naturally occurring metallic element that is found in air, water and soil. Natural sources of mercury (primarily in elemental form) include outgassing from volcanoes and evaporation from natural bodies of water. Since the beginning of the industrial age, human activities have increased the amount of mercury releases to the environment. The combustion of fossil fuels such as coal represents the largest source category of mercury emissions in the U.S. In fact, the Mercury Study in 1997 by U.S. EPA indicated that coal-fired power plants contribute about 34 percent of the total man-made mercury emissions. Also, the study indicated that more than two thirds of the U.S. anthropogenic emissions came from three source categories; namely, coal fired-power plants, municipal waste combustion and medical waste incineration. (Mercury Study, 1997).

**Figure 2.1 – U.S. Anthropogenic Emissions 1994-1995***

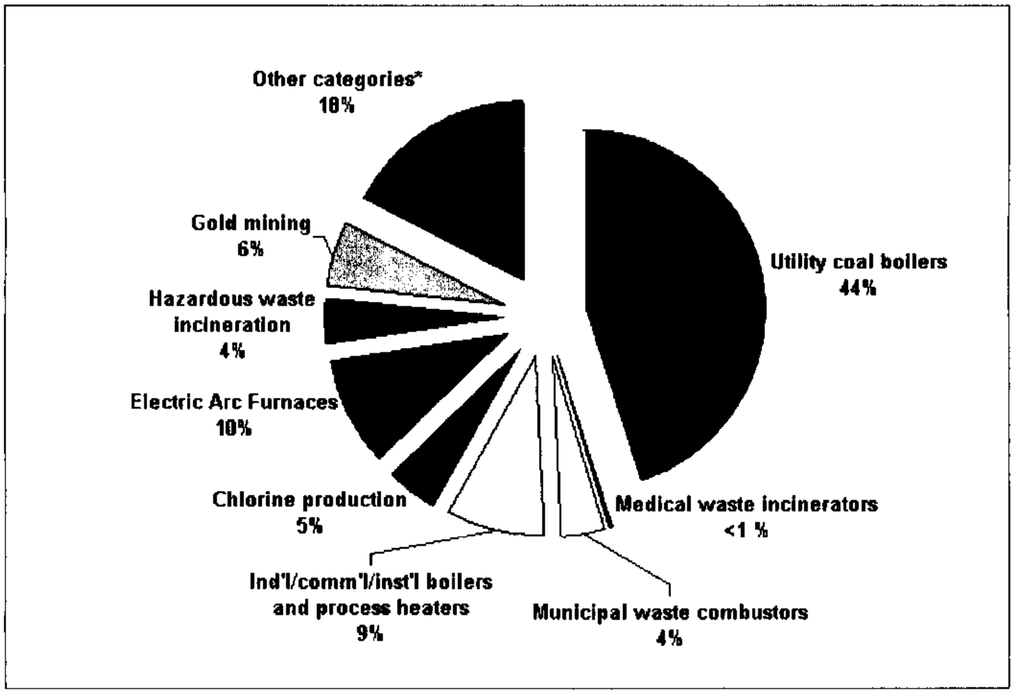



*From Table 5-1 Point Estimates of 1994-1995 National Mercury Emission Rates by Category, Volume II, Mercury Study Report to Congress

U.S. EPA improved its estimates on mercury source emissions across the U.S. (Figure 2.2) and presented the source distributions at a recently concluded mercury workshop sponsored by the Lake Michigan Air Directors Consortium (LADCO) (Alex Cain, U.S. EPA Presentation, February 22, 2006, Rosemont, IL). Relative to earlier estimates in the Mercury Study, there has been a reduction in emissions from municipal waste combustors and medical waste incinerator source categories, largely attributed to the effectiveness of maximum achievable control technology (MACT) standards for these source categories that require at least 90 percent reduction of mercury from 1990 levels.

A number of other federal and state regulations and/or programs have been implemented to address mercury emissions from other source categories, including commercial and industrial boilers, electric arc furnaces and chlor-alkali production. Similar to the inventory assessment in the Mercury Study, the 2002 estimates show that coal–fired power plants remain the largest unregulated source category of mercury emissions. Approximately 44 percent of the U.S. anthropogenic mercury emissions are attributed to coal-fired power plants from a total of about 111.4 total tons of mercury annually, estimated by U.S. EPA.

**Figure 2.2 - U.S. Anthropogenic Emissions 2002***

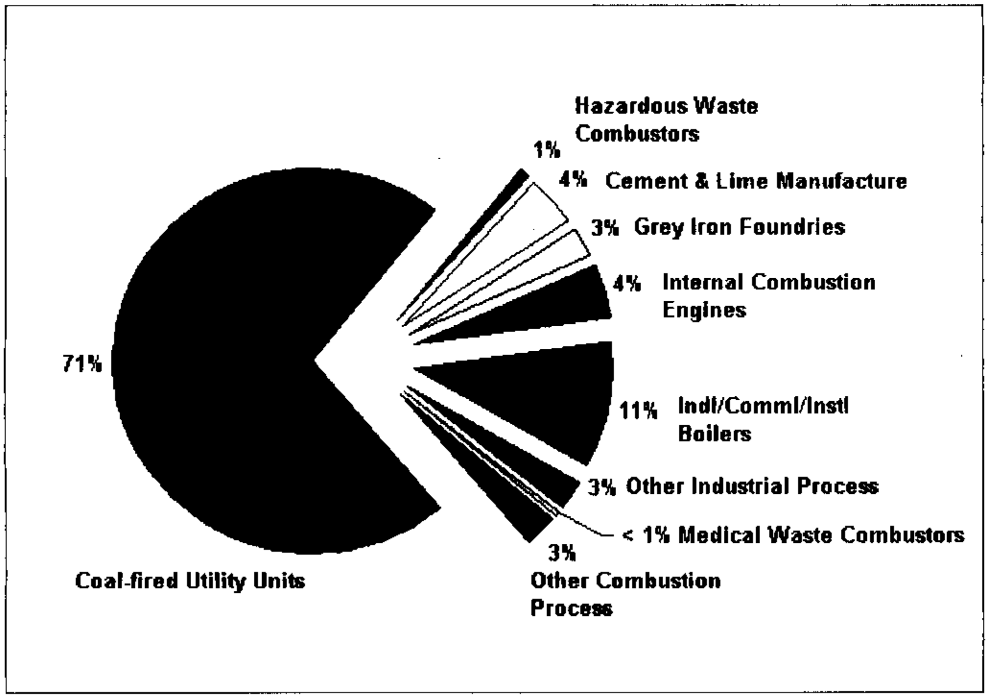



*USEPA Presentation, LADCO Mercury Workshop, O'Hare International Center Auditorium, Rosemont, Illinois, Feb. 22, 2006

### 2.2.2 Illinois Sources of Mercury Emissions

In Illinois, the largest source category of anthropogenic mercury emissions are coal-fired power plants. Using 2002 data from the National Emissions Inventory (NEI), the coal-fired power plants category contributed over 70 percent of the total mercury emissions in the State. The State's next largest source of mercury emissions is the Industrial/Commercial/Institutional boilers category, which accounted for about 11 percent of the total. Other source categories, in descending order of mercury emissions contribution, include Cement and Lime Manufacture, Internal Combustion Engines, Grey Iron Foundries, Other Combustion Processes (residential boilers, institutional boilers, crematories), Other Industrial Processes, Hazardous Waste Incinerators and Medical Waste Incinerators.

**Figure 2.3 – 2002 Illinois Anthropogenic Sources of Mercury Emissions***




*(based from 2002 National Emissions Inventory data)

### 2.2.3 Mercury Emissions from Illinois' Electric Generating Units

There were 64 coal-fired electric generating units in Illinois that were included in U.S. EPA's 1999 Information Collection Request (ICR) to support the development of the federal CAMR (Table 2.1). According to U.S. EPA's estimates, Illinois power plants emitted about 2.99 tons or 5,980 pounds of mercury in 1999. This estimate for Illinois was taken from the national estimates, which were calculated by U.S. EPA based on the collection of data for over 152,000 coal shipments from 1,143 units at 464 coal-fired power plants. *(See U.S. EPA, Electricity Utility Steam Generating Unit Mercury Emissions Information Collection Effort, Appendix B Background Material of Methodology Used to Estimate 1999 National Mercury Emissions from Coal-Fired*

*Electric Utility Boilers, September 15, 2000*). This number represents U.S. EPA's best estimate of mercury emissions from Illinois coal and oil fired EGUs, but is not an actual measurement.

**Table 2.1 – 1999 ICR List of Illinois Coal-fired Electric Generating Units***

| FACILITY NAME | ORIS CODE | UNITID | Acid Rain Program | Hg MACT | Hg Allocation | CAMD Online Date |
|---|---|---|---|---|---|---|
| Baldwin | 889 | 1 | Yes | Yes | Yes | 7/13/1970 |
| Baldwin | 889 | 2 | Yes | Yes | Yes | 5/21/1973 |
| Baldwin | 889 | 3 | Yes | Yes | Yes | 6/20/1975 |
| Coffeen | 861 | 01 | Yes | Yes | Yes | 12/20/1965 |
| Coffeen | 861 | 02 | Yes | Yes | Yes | 9/16/1972 |
| Crawford | 867 | 7 | Yes | Yes | Yes | 5/23/1958 |
| Crawford | 867 | 8 | Yes | Yes | Yes | 4/13/1961 |
| Dallman | 963 | 31 | Yes | Yes | Yes | 6/1/1968 |
| Dallman | 963 | 32 | Yes | Yes | Yes | 6/1/1972 |
| Dallman | 963 | 33 | Yes | Yes | Yes | |
| Duck Creek | 6016 | 1 | Yes | Yes | Yes | 6/26/1976 |
| E D Edwards | 856 | 1 | Yes | Yes | Yes | 5/1/1960 |
| E D Edwards | 856 | 2 | Yes | Yes | Yes | 6/1/1968 |
| E D Edwards | 856 | 3 | Yes | Yes | Yes | 6/23/1972 |
| Fisk | 886 | 19 | Yes | Yes | Yes | 3/14/1959 |
| Grand Tower | 862 | 07 | Yes | Yes | Yes | 3/1/1951 |
| Grand Tower | 862 | 08 | Yes | Yes | Yes | 3/1/1951 |
| Grand Tower | 862 | 09 | Yes | Yes | Yes | 4/2/1958 |
| Havana | 891 | 9 | Yes | Yes | Yes | 6/6/1978 |
| Hennepin | 892 | 1 | Yes | Yes | Yes | 6/1/1953 |
| Hennepin | 892 | 2 | Yes | Yes | Yes | 5/14/1959 |
| Hutsonville | 863 | 05 | Yes | Yes | Yes | 2/1/1953 |
| Hutsonville | 863 | 06 | Yes | Yes | Yes | 7/1/1954 |
| Joliet 29 | 384 | 71 | Yes | Yes | Yes | 4/9/1965 |
| Joliet 29 | 384 | 72 | Yes | Yes | Yes | 4/9/1965 |
| Joliet 29 | 384 | 81 | Yes | Yes | Yes | 3/21/1966 |
| Joliet 29 | 384 | 82 | Yes | Yes | Yes | 3/21/1966 |
| Joliet 9 | 874 | 5 | Yes | Yes | Yes | 6/12/1959 |
| Joppa Steam | 887 | 1 | Yes | Yes | Yes | 8/1/1953 |
| Joppa Steam | 887 | 2 | Yes | Yes | Yes | 9/1/1953 |
| Joppa Steam | 887 | 3 | Yes | Yes | Yes | 5/1/1954 |
| Joppa Steam | 887 | 4 | Yes | Yes | Yes | 8/1/1954 |
| Joppa Steam | 887 | 5 | Yes | Yes | Yes | 6/5/1955 |
| Joppa Steam | 887 | 6 | Yes | Yes | Yes | 8/5/1955 |
| Kincaid | 876 | 1 | Yes | Yes | Yes | 6/7/1967 |
| Kincaid | 876 | 2 | Yes | Yes | Yes | 6/10/1968 |
| Lakeside | 964 | 7 | Yes | Yes | Yes | |
| Lakeside | 964 | 8 | Yes | Yes | Yes | |
| Marion | 976 | 1 | Yes | Yes | Yes | 1/1/1995 |
| Marion | 976 | 2 | Yes | Yes | Yes | 1/1/1995 |
| Marion | 976 | 3 | Yes | Yes | Yes | 10/1/1963 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Marion | 976 | 4 | Yes | Yes | Yes | 10/1/1978 |
| Meredosia | 864 | 01 | Yes | Yes | Yes | 6/1/1948 |
| Meredosia | 864 | 02 | Yes | Yes | Yes | 6/1/1948 |
| Meredosia | 864 | 03 | Yes | Yes | Yes | 6/1/1948 |
| Meredosia | 864 | 04 | Yes | Yes | Yes | 6/1/1948 |
| Meredosia | 864 | 05 | Yes | Yes | Yes | 7/14/1960 |
| Newton | 6017 | 1 | Yes | Yes | Yes | 11/18/1977 |
| Newton | 6017 | 2 | Yes | Yes | Yes | 12/1/1982 |
| Powerton | 879 | 51 | Yes | Yes | Yes | 7/11/1973 |
| Powerton | 879 | 52 | Yes | Yes | Yes | 7/11/1973 |
| Powerton | 879 | 61 | Yes | Yes | Yes | 9/7/1976 |
| Powerton | 879 | 62 | Yes | Yes | Yes | 9/7/1976 |
| Vermilion | 897 | 1 | Yes | Yes | Yes | 5/19/1955 |
| Vermilion | 897 | 2 | Yes | Yes | Yes | 11/25/1956 |
| Waukegan | 883 | 7 | Yes | Yes | Yes | 6/11/1958 |
| Waukegan | 883 | 8 | Yes | Yes | Yes | 7/2/1962 |
| Waukegan | 883 | 17 | Yes | Yes | Yes | 1/14/1952 |
| Will County | 884 | 1 | Yes | Yes | Yes | 7/27/1955 |
| Will County | 884 | 2 | Yes | Yes | Yes | 3/14/1955 |
| Will County | 884 | 3 | Yes | Yes | Yes | 6/28/1957 |
| Will County | 884 | 4 | Yes | Yes | Yes | 6/25/1963 |
| Wood River | 898 | 4 | Yes | Yes | Yes | 6/1/1954 |
| Wood River | 898 | 5 | Yes | Yes | Yes | 7/31/1964 |

*extracted from docket U.S. EPA OAR2002-0056-6155

Since the implementation of the Acid Rain Program (ARP) under Title IV of the federal Clean Air Act, a number of Illinois' power plants have switched to low sulfur, western, subbituminous coal in lieu of installing control technology to achieve compliance with the Acid Rain Program's sulfur dioxide ($SO_2$) standards. Currently, more than 80 percent of Illinois coal-fired power plants are using subbituminous coal, mostly coming from the Powder River Basin (PRB) area. Other Illinois power plants, however, installed SO2 controls, e.g., wet or dry flue gas desulfurization or scrubbers, to comply with $SO_2$ emission standards requirements.

PRB coals are lower in sulfur and have a lower average heating value relative to the sulfur control and heating value for eastern, bituminous coals. Illinois believes that the level of mercury emissions estimates in the 1999 ICR is not representative of Illinois mercury emissions because of the increase in PRB coal usage/switch and the existing air pollution control configurations in 2002 that are less efficient in capturing the form of mercury resulting from the combustion of subbituminous coal. The amount of coal sample-tested for mercury and stack testing data from the 1999 ICR offers the most comprehensive mercury data available that can be used to estimate mercury emissions for later years. Hence, Illinois EPA has estimated (2002) mercury emissions from Illinois' coal-fired EGUs by using the methodology employed by U.S. EPA in its Emissions and Generation Resource Integrated Database (eGrid) (http://www.epa.gov/cleanenergy/egrid/index.htm) for power plant emissions (and also as adopted by the Commission for Environmental Cooperation (CEC) in their estimate of power plant emissions for North America (*See: North American Power Plant Air Emissions" by Paul Migler and Chris Van Aten, Commission for Environmental Co-operation of North America" (Montreal, Quebec 2004)* , i.e., using estimating parameters such as plant specific ratio from the 1999 ICR and coal usage reported in 2002 by power plants to the U.S. Department of Energy's (DOE) Energy Information Administration (EIA). The plant specific ratio was derived by dividing mercury emissions estimate in 1999 ICR by the coal usage for each plant in 1999. This plant specific ratio was then used to scale the estimates for 2002 using the reported coal usage for each plant in 2002. Using this methodology, Illinois' estimated mercury emissions from coal-fired power plants for 2002 was estimated at around 7022 pounds.

## 3.0 Mercury Impacts on Human Health

Various chemical forms of mercury, e.g. elemental mercury, inorganic mercury salts, and organic alkyl mercury compounds, are known to induce toxic responses in the human body. For the known environmental exposure pathways of mercury compounds to human beings, it is generally felt that methylmercury ingestion through fish consumption poses the greatest exposure risk to human beings. The Minamata, Japan and Niigata Prefecture (Japan) methylmercury poisoning incidents of the 1950s and 1960s, respectively, are well known examples of mercury poisoning epidemics resulting from fish consumption. A significant mercury poisoning event in Iraq in the 1970s was due to ingestion of flour made from grain seeds treated with methylmercury. These acute poisoning incidents have yielded information on the symptoms and neurological effects of methylmercury poisoning, as have reports regarding low-level exposures. The effects can be different for an adult as compared to an infant or fetus, but the infant and fetus are known to be more sensitive to the neurotoxin. Sensory impairment, speech impairment, muscle weakness, tremor, mental deficits (memory, learning), malformed brains, hypersensitive reflexes, and mental retardation are included among the known neuropathological manifestations of methylmercury poisoning in humans.

As a result of the mass methylmercury poisoning incidents previously mentioned, three longitudinal prospective epidemiological studies---studies in which individuals are tested on more than one occasion---were conducted in the late 1970s and 1980s to assess human developmental effects linked to mercury exposure from predominantly fish-eating populations. Scholastic and psychological test batteries were administered in all of these studies. A case-control study---a study investigating those with and those without a particular health condition---was conducted in New Zealand of 74 children representing white, Maori, and Pacific Islander ethnic groups. When tested at the age of four, 52% of this group had abnormal results when compared to 17% of the children in a control group. A study on approximately 750 children (black population) on the Seychelles Islands yielded results, from evaluations at 66 months of age, for which evidence of adverse effects was not strong. Further testing of the Seychelles Island population at 9 years of age yielded one adverse association. The results of this study contrast markedly with one involving over 900 children (white population) on the Faroe Islands. Statistically significant associations were found between umbilical cord blood mercury levels and poorer performance on certain assessment tests for the Faroe Island population. A recent analysis of all three longitudinal studies indicates that the results are not discordant with respect to mercury effects on IQ. This integrative analysis yielded a decrement of 0.13 IQ point for each 1 ppm increase in maternal hair mercury. Other prospective studies---studies aimed at determining the onset of disease---have been conducted in the Philippines, Poland, and the United States. Results consistent with those from the Faroe Islands study have been reported for these studies.

Cross-sectional studies---those which compare the current health and exposure status of study members, and then evaluate similarities---assessing development in children from the Madeira Islands, Brazilian Amazon, French Guiana, and Ecuador have shown test outcomes significantly associated with the metrics of mercury hair concentrations or blood mercury levels. Similarly, cognitive function and motor function tests on adults in Italy, United States, Brazil and Quebec have shown associations with total urinary mercury, mercury in blood, and/or hair mercury content.

The physiological and behavioral effects of developmental exposure to methylmercury have been studied in monkeys and rodents and provide insights for human neuropathological effects. In all species (including humans), exposure at high doses results in damage to the brain and decreased brain size. Diminished visual and auditory functionality, decreased motor function and cognitive impairment have been demonstrated in test animals subject to elevated methylmercury exposure during development. Testing conducted on animals long after the cessation of dosing has shown that impairments are often permanent. Research has also provided evidence of delayed neurotoxicity---obesity, neuropsychological deficits, somatosensory damage, etc.---resulting from developmental exposure to methylmercury. There is also compelling evidence of delayed neurotoxicity in human populations long after the cessation of exposure to methylmercury. Though the precise molecular mechanism of delayed neurotoxicity is unknown, it is clear that exposure can result in permanent impairment.

The potential impact on the human body of methylmercury exposure includes evidence for cardiovascular and coronary disease. In a recent study of 2500 men in Finland, the highest measured hair mercury concentrations were associated with increased incidences of myocardial infarction. The results of this study also indicate that high levels of methylmercury in the body may negate the beneficial effects of fish oils in protecting against coronary disease.

The NHANES survey and other studies intended to provide information on mercury body burdens in the U.S. population provide evidence of a strong association between fish consumption and increased mercury levels. For some populations, a substantial percentage of individuals have methylmercury body burdens greater than that associated with the reference dose. The reference dose (RfD) for methylmercury is 0.1

micrograms/kg/day, and it represents an estimation of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime. It is not a "bright line" cutoff for known health effects versus no-effect levels. The RfD is based on the lower bound of a 95% confidence interval on the dose, which produces a 5% effect level (in addition to a 5% background level), and it includes an uncertainty factor of 10 to account for maternal to fetal dose ratio variability and an individual's dose sensitivity. The Centers for Disease Control has estimated that approximately 6% of women of childbearing age have blood mercury levels at or exceeding the reference dose. Umbilical cord blood mercury concentration of 5.8 micrograms/liter (on average, this is equated to a maternal blood level of 3.4) corresponds to the U.S. EPA reference dose. This in turn corresponds with a hair mercury level of 0.65 ppm. A model has been used which provides an estimate of the maternal intake of methylmercury relative to blood mercury levels under steady state conditions. A median intake value of 0.81 micrograms/kg/day would be associated with an umbilical cord blood concentration of 58 micrograms/liter.

Researchers have estimated the costs of environmental exposure to methylmercury associated with IQ decrement and increased occurrences of mental retardation. Using data from the Faroe Islands study, the loss in lifetime earnings associated with IQ decrement has been estimated at $8.7 billion annually (in Year 2000 US dollars). The cost of increased occurrences of mental retardation (excluding lost wages) was estimated at $2.0 billion annually. Neuropsychological effects not related to IQ decrement (e.g. attention deficits), potential cardiovascular and coronary effects, potential blood pressure effects, and potential cognitive deficits, which are not monetized, result in cost underestimates related to methylmercury exposure. (The majority of statements made in this portion of the report are based, at least in part, on statements contained within the Michigan's Electric Utility Workgroup Final Report on Mercury Emissions from Coal-Fired Power Plants (June 20, 2005) (Michigan Mercury Report)) and the attached Appendix A, *"Review of the Nervous System and Cardiovascular Effects of Methylmercury Exposure" (March 2006).)*

### 3.1 Quantifying and Monetizing Impacts of Mercury in Illinois

Elevated exposure to mercury through the consumption of contaminated fish adversely affects the economy of a given region through direct effects to human health. Studies to quantify and monetize the benefits to human health as a result of reductions in mercury emissions from U.S. power plants have been conducted by U.S. EPA, NESCAUM, Harvard, and Trasande et al. They have been summarized in Section 2.5.4 of Michigan's Mercury Electric Utility Workgroup's Final Report on Mercury Emissions from Coal-fired Power Plants. The following summaries are taken from that report.

**U.S. EPA CAMR Regulatory Impact Analysis (CAMR RIA)**

In the U.S. EPA's final CAMR released March 15, 2005, the benefits of reduced mercury emissions from the utility sector were estimated based on monetized "improvements in IQ decrements" for a subset of the U.S. population exposed *in utero* which included the freshwater angler population (women of childbearing age) in the eastern half of the U.S. EPA also analyzed a smaller subset of the population who consume greater amounts of fish than the general population, which included subsistence fishers, certain Native Americans, and Asian Americans.

U.S. EPA reasoned that since the largest change in power plant deposition associated with the final Clean Air Interstate Rule (CAIR) and CAMR programs would occur in the eastern-half of the U.S., the unquantified benefits for the western-half of the U.S. would be expected to be quite small (CAMR RIA; Section 10-1). U.S. EPA stated that the focus of their analysis was limited to freshwater fish consumption exposure due to limitations in the modeling of how changes in mercury deposition will affect fish tissue concentrations from other consumption pathways (namely ocean fish consumption) (CAMR RIA; Section 10-1). EPA's analysis further indicated that only freshwater fish are significantly impacted by U.S. power plants. EPA did recognize, however, that ocean fish consumption is the predominant pathway for methylmercury exposure in the U.S. (approximately 90%) (CAMR RIA; Section 10-144). EPA stated that

*"exclusion of these commercial pathways means that this benefit analysis, while covering an important source of exposure to domestic mercury emissions excludes a large and potentially important group of individuals."*

EPA's benefit estimates represent the monetary values of expected IQ improvements assessed in terms of future foregone earnings recovered after reductions are achieved via the final CAMR. This considered, EPA assessed exposure reductions for each of the regulatory options utilizing various control scenarios, timelines, and lag times between reductions and subsequent benefits. EPA's core analysis used a primary dose-response curve that implies that each 1 part per million (ppm) increase in mercury in hair results in a 0.13 IQ decrement. The monetized value of avoided IQ decrements was estimated to be between $0.8 and $3.0 million annually at a 3% discount rate (1999 dollars), under CAMR Option 1 assuming no threshold (CAMR RIA, Table 11-7). Combined benefits of CAIR and CAMR resulted in a range of estimated benefits between $10.4 to $46.8 million annually (1999 dollars) (CAMR RIA; Table 10-1c). The benefits associated with each of the emission reduction scenarios were estimated as the difference (reduction) in the total value of IQ losses, going from the relevant baseline scenario to conditions with emissions reductions in place (CAMR RIA; Table 10-11).

U.S. EPA recognized that full scale IQ might not be the cognitive endpoint that is most sensitive to prenatal mercury exposure (CAMR RIA; Table 9-9). They state that their benefits assessment has several known uncertainties and biases and that these biases are both in the upward and downward direction but that, taken together

……… *"the Agency believes that the benefits presented in this section likely underestimate the total benefits of reducing mercury emissions from power plants due to the potential health effects and potentially exposed populations that are not quantified in this analysis."*

In addition to quantifying benefits based on IQ improvements, U.S. EPA acknowledged that other health and ecosystem benefits (other neurological effects besides IQ, cardiovascular, genotoxic, immunotoxic, and ecological) may also result from reductions. However, they did not feel confident in quantifying these potential benefits. These benefits were addressed qualitatively and listed in Table 10-45 in EPA's CAMR RIA. Furthermore, U.S. EPA performed an illustrative analysis to monetize co-benefits of avoided premature adult mortality expected to result from reductions in emissions of PM2.5 (fine particulate matter with a diameter of ÿ 2.5 microns) if ACI with the addition of a polishing baghouse is used (such as TOXECONTM). Potential benefits resulting from Option 1 ranged from $1.5 to $44 million depending upon the availability of advanced sorbents technology. Similarly, potential benefits under Option 2 ranged from $1.5 to $130 million, again depending upon the status of advanced sorbent technology. The explanation and rationale for U.S. EPA's approach is described in Johnson (2005), as well as CAMR RIA.

**Harvard / NESCAUM Study**

In a separate analysis, researchers from the Harvard Center for Risk Analysis, on contract with the Northeast States for Coordinated Air Use Management (NESCAUM), assessed the health benefits of reducing mercury from U.S. coal-fired power plants based on targeted emission amounts similar to those U.S. EPA had proposed in their draft maximum achievable control technology (MACT) standard (i.e. preliminary reduction to 26 tons of mercury emissions annually, and final reduction to 15 tons after 2018). The researchers relied on regional deposition modeling results from U.S. EPA's analysis of the Clear Skies Initiative as the basis for expected changes in fish tissue mercury levels. Modeling was based on five freshwater regions (Northeast, Mid-Atlantic, Southeast, Midwest, and West) and three saltwater regions (Atlantic Coastal, Gulf of Mexico, and All Other Waters). Estimated expected decreases in freshwater regions and the Atlantic Coastal and Gulf of Mexico regions ranged from 1% to 10%. Estimated expected decreases to the "All Other Waters" region was assumed to be proportional to the change in total global emissions which equates to less than 1%.

The health effects considered in this analysis were "cognitive abilities" (including IQ), and also cardiovascular effects, which were not quantitatively monetized by U.S. EPA (CAMR RIA). Human exposure pathways considered included commercially and non-commercially harvested fish based on FDA and U.S. EPA consumption rates. The exposed population for calculating IQ benefits consisted of U.S. women of childbearing age with estimated exposure levels above the RfD (roughly 9% of U.S. females). The exposed population for calculating cardiovascular benefits was the U.S. population of men and women over the age of 39 (based on 2000 Census data). A slope estimate of the dose-response relationship was estimated to be 0.6 IQ points lost per 1 ppm increase in hair mercury concentration which was stated as a central tendency estimate based on existing literature. They utilized a cost-of-illness approach to derive a value of $16,500 (year 2000 dollars) for each IQ decrement. Their results indicated average national benefits due to IQ increases alone in the annual birth cohort ranged between $75 and $194 million (after the MACT Phase I 26 ton cap) and between $119 and $288 million (after the MACT Phase II 15 ton cap), depending on whether or not a neurotoxicity threshold is assumed (all dollar values are year 2000). The researchers assumed that *"...increases in a child's intelligence quotient (IQ) that result from decreases in intrauterine methyl mercury exposures capture some of the neurodevelopmental delays reported in positive epidemiological studies."* They indicated that these values were likely a conservative estimate of the total value individuals place on IQ changes, because such changes may have value that is independent of their impact on lifetime earnings.

According to the Harvard/NESCAUM study, the potential cardiovascular effects of methyl mercury exposure are less well understood and therefore any monetized values representing cardiovascular benefits are accompanied with a great deal of uncertainty. It is noted that this uncertainty was the U.S. EPA (CAMR RIA) rationale for focusing their quantitative analysis on IQ benefits, which are better established including an available model for monetizing benefits. The Harvard/NESCAUM study derived two estimates based on epidemiological studies of methylmercury exposure in males who consumed non-fatty freshwater fish. The endpoints evaluated in these studies were increased risk of non-fatal myocardial infarction and premature mortality from myocardial infarction. Using a cost-of-illness approach (2000 value year), the estimated value of myocardial infarction was $50,000 per individual. Using a willingness-to-pay approach for the same value year, the estimated value of premature fatality was $6,000,000 per individual. Total benefits of $4.9 billion annually due to reduced cardiovascular disease were estimated, assuming benefits are extended to the entire adult population. The authors strongly cautioned against the use of these predicted benefits until further study and review was available to support the relationship between increased cardiovascular risk and methyl mercury exposure.

### Trasande et al. Study

In another available study, Trasande et al. (2005) estimated the national, annual cost associated with methylmercury exposure due to lost productivity during the lifetimes of children who were exposed in utero resulting in neurological effects (IQ loss). The rationale for this approach was that loss of intelligence causes diminished economic productivity that persists over the entire lifetime of affected children. Their cost estimates included direct costs of health care, costs of rehabilitation, and lost productivity. They also estimated the fraction of that loss which is attributable to mercury emissions from U.S. power plants. The exposed population is the estimated number of children born each year with cord blood mercury levels greater than the level associated with the RfD, which is protective of effects on IQ. That information was obtained from national blood mercury prevalence data from the CDC. The resulting at-risk subgroup was estimated as between 316,588 and 637,233 exposed children, which includes children exposed through any maternal consumption pathway including consumption of freshwater and ocean fish. The estimated cost of loss in productivity due to the reduction in intelligence was estimated to be between $2.2 and $43.8 billion, depending on fetal effect level assumptions. Based on these estimates, $1.3 billion (range: $0.1 to $6.5 billion) annually was attributable to emissions from U.S. coal-fired power plants according to the researchers. This study did not discuss or include quantification or monetization of potential cardiovascular effects of methylmercury exposure (Trasande et al., 2005).

Table 3.1 summarizes the key assumptions and value estimates made in each of the three benefits analyses presented above.

**Table 3.1 Comparison of Benefits Analyses for Neurological Effects in the U.S.**

| Assumptions/ Estimates | EPA | HARVARD/NESCAUM | TRASANDE |
|---|---|---|---|
| **Benefit Estimates (annually)** | In 1999 dollars:<br>Zero Out of EGU Emissions (relative to 2001 baseline) **\$8.9 to \$37.0 million**<br><br>2020 Base Case with CAIR (relative to 2001 baseline) **\$9.6 to \$43.8 million**<br><br>CAMR Option 1 (relative to 2020 base case with CAIR) **\$0.8 to 3.0 million**<br><br>Combined Benefits of CAIR and CAMR **\$10.4 to \$46.8 million** | In 2000 dollars:<br>**\$75 to \$194 million** (after 26 ton cap in 2010)<br><br>**\$119 to 288 million** (after 15 ton cap in 2018) | In 2000 dollars:<br>**\$2.2 to \$43.8 billion** (due to worldwide anthropogenic sources)<br><br>**\$0.4 to \$15.8 million** (due to U.S. anthropogenic sources<br><br>**\$0.1 to \$6.5 billion** (due to U.S. coal-fired power plants) |
| **U.S. Utilities' Contribution to Modeled Exposure Scenario** | For the U.S. freshwater fish consumers, 1%* of the mercury exposure is attributable to U.S. power plants. | Expected decreases in U.S. utilities' contribution to mercury exposure after MACT reductions would be 1% to 10% for freshwater, Atlantic Coastal, and Gulf of Mexico regions and less than 1% for All Other Waters (U.S. contribution to global pool) | U.S. power plants contribute 41% of U.S. anthropogenic emissions, which contribute 18 to 36% of worldwide anthropogenic emissions |
| **Exposure** | Freshwater fish consumption (non-commercial) | Freshwater and ocean fish consumption (commercial and non-commercial) | Children born to women with blood mercury levels indicating exposure above the RfD |
| **Exposed Population** | Freshwater angler population in the Eastern half of U.S. in the 77th to 100th consumption percentiles (approx. 420,000 to 580,000 persons) | Annual birth cohort (assuming no threshold) and approximately 9% of annual birth cohort (assuming threshold at RfD)(2000 Census). | Estimated number of children born each year with *in utero* mercury exposures above the RfD (between 316,588 and 637,233 children) |
| **IQ Decrement** | 0.13 IQ points lost per 1ppm mercury in hair | 0.6 IQ points lost per 1ppm mercury in hair | 1.5 (base case) and 0.85 to 2.4 (outer bounds) IQ points lost per doubling of blood mercury |
| **IQ Value** | \$8,800 per IQ improvement per capita | \$16,500 per IQ decrement per capita | Loss of 1 IQ point = decrease in lifetime earnings:<br>Boys \$1,032,002<br>Girls \$ 763,468 |

| | | | |
|---|---|---|---|
| **Cost Approach** | Monetized "improvements in IQ decrements" in terms of future foregone earnings recovered after reductions under CAMR/CAIR are achieved | Cost of illness approach as dollars saved (in terms of future foregone earnings) after reductions under proposed MACT rule are achieved | Cost of illness approach as lifetime lost productivity (in terms of lost productivity and direct costs of health care and rehabilitation) from exposure to mercury above the RfD |

* 1% is the product of combining the 8% contribution of U.S. utilities to U.S. deposition (and fresh water fish levels); from page 8 to 14 of CAMR RIA and the 13% contribution of wild fresh water fish to the U.S. fish diet; from page 4 to 46 of CAMR RIA.
** Trasande et al. attributed 33% of the total cost of IQ deficits to U.S. power plants. This equates to $1.3 billion out of a total cost of $3.9 billion.

## 4.0 Mercury Impaired Waters in Illinois

High mercury levels in fish tissue pose a public health risk, but their presence also imposes a regulatory requirement for Illinois under the federal Clean Water Act (CWA). This section describes the applicability of the Clean Water Act to mercury-impaired waters, how mercury impairments have been identified, an analysis of the amount of mercury reduction needed in fish tissue to reach attainment, sources of mercury loading and the experience of two other states in addressing mercury contamination of fish tissue.

## 4.1 Background on Clean Water Act Requirements

### 4.1.1 Water Pollution Control Regulatory Scheme/Water Quality Standards

Water pollution control programs are designed to protect the "beneficial uses" of the water resources of the state. Each state has the responsibility to set water quality standards that protect these beneficial uses, also called "designated uses." Illinois waters are designated for various uses including aquatic life, wildlife, agricultural use, primary contact (e.g., swimming, water skiing), secondary contact (e.g., boating, fishing), industrial use, fish consumption, drinking water, food-processing water supply and aesthetic quality.

**Table 4.1 Illinois Designated Uses and Applicable Water Quality Standards.**

| Illinois EPA Designated Uses | Illinois Waterbodies in which the Designated Use and Standards Apply[1] | Applicable Illinois Water Quality Standards |
|---|---|---|
| *Aquatic Life* | Streams, Inland Lakes | General Use Standards |
| | Lake Michigan-basin waters | Lake Michigan Basin Standards |
| ***Aesthetic Quality*** | Streams, Inland Lakes | General Use Standards |
| | Lake Michigan-basin waters | Lake Michigan Basin Standards |
| *Indigenous Aquatic Life* | Specific Chicago Area Waterbodies | Secondary Contact and Indigenous Aquatic Life Standards |
| *Primary Contact (Swimming)* | Streams, Inland Lakes | General Use Standards |
| | Lake Michigan-basin waters | Lake Michigan Basin Standards |
| *Secondary Contact* | Streams, Inland Lakes | General Use Standards |
| | Lake Michigan-basin waters | Lake Michigan Basin Standards |
| | Specific Chicago Area Waterbodies | Secondary Contact and Indigenous Aquatic Life Standards |
| *Public and Food Processing Water Supply* | Streams, Inland Lakes, Lake Michigan-basin waters | Public and Food Processing Water Supply Standards |
| *Fish Consumption* | Streams, Inland Lakes | General Use Standards (Human Health) |
| | Lake Michigan-basin waters | Lake Michigan Basin Standards (Human Health) |
| | Specific Chicago Area Waterbodies | Secondary Contact and Indigenous Aquatic Life Standards |

**1. As defined in 35 Ill. Adm. Code 302.201 and 302.303.**

The Illinois Pollution Control Board (Board) is responsible for setting water quality standards to protect designated uses in waterbodies. The federal Clean Water Act requires the states to review and update water quality standards every three years. Illinois EPA, in conjunction with U. S. EPA, identifies and prioritizes those standards to be developed or revised during this three-year period. Illinois EPA is responsible for developing scientifically-based water quality standards and proposing them to the Illinois Pollution Control Board for adoption into State rules and regulations.

The Board has established four primary sets (or categories) of narrative and numeric water quality standards for surface waters. Each set of standards is designed to help protect various designated uses established for each category. The fish consumption use is covered under the general use category.

The Board's *General Use Standards* (35 Ill. Adm. Code Part 302, Subpart B) - apply to almost all waters of the State and are intended to protect aquatic life, wildlife, agricultural, primary contact, secondary contact, and most industrial uses. These General Use standards are also designed to ensure the aesthetic quality of the state's aquatic environment and to **protect human health from disease or other harmful effects that could occur from ingesting aquatic organisms taken from surface waters of the State** (*Emphasis added*).

The general use standards for mercury include standards for protection of aquatic life and human health. Part 302 of 35 Ill Adm. Code, Subpart B, lists acute and chronic standards for protection of aquatic life which are 2.2 and 1.1 micrograms per liter dissolved mercury, respectively. Sections 302.208 (c) and (f) of 35 Ill. Adm. Code identify a much more stringent standard for human health protection: 0.012 micrograms per liter total mercury. This level is the national criterion applicable to water to address the potential for mercury to bioaccumulate in fish tissue.

### 4.1.2 Point Source Pollution Control

Discharges that enter surface waters through a pipe, ditch or other well-defined point of discharge are broadly referred to as "point sources." Common point source discharges include wastewater treatment facilities serving municipalities, industries, residential developments, retail and commercial complexes, schools, mobile home parks, military installations, state parks, resorts/campgrounds, prisons, and individual residences. Other wastewater point source discharges can come from municipal combined sewer overflows (CSOs), concentrated animal feeding operations, mines, groundwater remediation projects, and water treatment plants.

The National Pollutant Discharge Elimination System (NPDES) was established by the Clean Water Act in 1972 and has been administered by Illinois EPA since 1973. The program requires permits for the discharge of treated municipal effluent, treated industrial effluent, storm water and other discharges. The permits establish the conditions under which the discharge may occur, so that water quality and designated uses are protected, and establish monitoring and reporting requirements.

Permit conditions for mercury depend on the type of point source. Industrial discharges from processes involving mercury typically have mercury effluent limits that must be met, based on the water quality standard. All major municipal dischargers must monitor for very low levels of mercury.

### 4.1.3 Non-Point Source Pollution Control

Sources of water pollution other than point sources are designated as non-point sources and can have very significant impact on water quality. Non-point source pollution can result from precipitation moving over and through the ground that picks up pollutants from farms, cities, mined lands, and other landscapes and carries these pollutants into rivers, lakes, wetlands, and groundwater. Non-point source pollution can include numerous, diffuse sources such as clusters of malfunctioning septic systems. Atmospheric deposition of pollutants to water (from air emission sources) is another non-point water pollution source.

Discharges from these sources are mainly regulated through implementing corrective and preventative best management practices (BMPs) on a watershed scale.

### 4.1.4 Requirements to Report on Conditions of State Waters

According to Section 305(b) of the Clean Water Act and guidance provided by the U.S. EPA, each state, territory, tribe, and interstate commission (hereafter collectively called "state") must report to U.S. EPA on the quality of the surface water (e.g., lakes, streams, wetlands) and groundwater resources in their jurisdiction. Specifically, states must report the resource quality of their waters in terms of the degree to which the certain beneficial uses of those waters are attained. States are also required to report the reasons (causes and sources) if beneficial uses are not attained. In addition, states are required to provide an assessment of the water quality of all publicly-owned lakes, including the status and trends of such water quality as specified in section 314(a)(1) of the Clean Water Act.

Section 303(d) of the Clean Water Act requires states to submit to U.S. EPA a list of water quality-limited waters (i.e., waters where uses are impaired), the pollutants causing impairment to those waters and a priority ranking for the development of Total Maximum Daily Load (TMDL) calculations (including waters targeted for TMDL development within the next two years). This list is often called the 303(d) List.

The most current 305(b)/303(d) report is the draft "Illinois Integrated Water Quality Report and Section 303(d) Report, 2006" found at www.epa.state.il.us/water/watershed/reports/303d-report/2006/303d-report.pdf

### 4.1.5 303(d)/Total Maximum Daily Load Program (TMDL)

As stated earlier, section 303(d) of the federal Clean Water Act requires states to identify waters that do not meet applicable water quality standards or do not fully support their designated uses. States are required to submit a prioritized list of impaired waters, known as the 303(d) List, to the U.S. EPA for review and approval.

The CWA also requires that a TMDL be developed for each pollutant of an impaired waterbody. The establishment of a TMDL sets the pollutant reduction goal necessary to improve impaired waters. TMDL calculations determine the amount of a pollutant a waterbody can assimilate without exceeding the state's water quality standards or impairing the waterbody's designated uses. It determines the load (i.e., quantity) of any given pollutant that can be allowed in a particular water body. A TMDL must consider all potential sources of pollutants, whether point or nonpoint. It also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

After the reduced pollutant loads have been determined, an implementation plan is developed for the watershed spelling out the actions necessary to achieve the goals. The plan specifies limits for point source discharges and recommends best management practices for nonpoint sources. It also estimates associated costs and lays out a schedule for implementation

## 4.2 Identification of Mercury Impaired Waters in Illinois

### 4.2.1 Fish Consumption Advisories

Fish consumption advisories are issued when concentrations above human health-based limits of one or more of contaminants such as PCBs, chlordane, and mercury are detected in fish tissue. For mercury, there is a statewide fish consumption advisory in place in Illinois for all predator fish species. The advisories are based on tissue analysis of such sports fish as flathead catfish, all species of bass (including largemouth, smallmouth, spotted, white and striped), walleye, musky and northern pike. The human health-based concentrations in fish tissue for issuing the advisories due to mercury are presented in Table 4.2.

**Table 4.2. Current Human Health-Based Concentrations in Fish Tissue for Issuing Consumption Advisories due to Mercury (mg/kg in fillets, wet weight)**

| | Unlimited | 1 Meal per week | 1 Meal per month | 1 Meal per 2 Months | Do Not Eat |
|---|---|---|---|---|---|
| Women of Child-bearing Age and Children under 15 Years Old | $\leq 0.05$ | 0.06—0.22 | 0.23—0.95 | 0.96—1.89 | >1.89 |
| Men Over 15 Years Old and Women beyond Child-bearing Age | $\leq 0.15$ | 0.16—0.65 | 0.66—2.82 | 2.83—5.62 | >5.62 |

Consumption advice is given through the Illinois Fish Contaminant Monitoring Program (IFCMP), which consists of staff from the departments of Agriculture, Natural Resources, and Public Health, the Illinois Emergency Management Agency and Illinois EPA.

"One meal a week" (52 meals per year), "one meal a month" (12 meals per year) and "one meal every two months" (six meals per year) is advice for how long to wait before eating one's next meal of sport fish. "Do not eat" means no one should eat those fish because of very high contamination. One meal is assumed to be one-half pound of fish (weight before cooking) for a 150-pound person. The meal advice is equally protective for larger people who eat larger meals and smaller people who eat smaller meals.

The Illinois Department of Public Health advises:

> "In order to protect the most sensitive populations, pregnant or nursing women, women of childbearing age, and children less than 15 years of age are advised to eat no more than one meal per week of predator fish. Mercury is stored in the muscle of fish that eat mercury-contaminated food or live in mercury-contaminated water. Mercury is a metal that occurs naturally in small amounts in the environment. It also is thought to come from burning coal or trash, as well as from industrial waste. Mercury gets into lakes and rivers several ways, including rain and runoff. When conditions are right in the water, certain kinds of bacteria change inorganic mercury into methylmercury. This form of mercury is one of the most likely to get into fish." (http://www.idph.state.il.us/envhealth/factsheets/fishadv.htm)

Fish consumption use is associated with all waterbodies in the state. The assessment of fish consumption use is based on waterbody-specific fish tissue data and resulting fish consumption advisories issued by the IFCMP. In accordance with U.S. EPA guidance *("Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Section 303(d), 305(b) and 314 of the Clean Air Act", (U.S. EPA, July 29, 2005))*, general statewide fish-consumption advisories were not used to assess the attainment of fish consumption use. The IFCMP is responsible for determining the levels of contaminants in Illinois sport fish and issuing consumption advisories for species found to be contaminated above specified levels. In the past, the IFCMP relied on a criterion for mercury in sport fish of 0.5 mg/kg, developed by the Illinois Department of Public Health using data from the World Health Organization. This criterion was applied as a "bright line" value, with samples exceeding the criterion given "Do not eat" advice for the entire population and samples below the criterion placed in the "Unlimited" category. With the adoption of the *Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory* (Anderson et al.; 1993), as the basis for developing sport fish advisories by the IFCMP, it became necessary to replace the bright line approach for mercury in order to make the mercury advisories consistent with the five categories of consumption advice specified in the Protocol. Since the protocol did not contain a Health Protection Value (HPV) for mercury at that time, the IFCMP adopted U.S. EPA's Reference Dose for methylmercury of 0.0001 mg/kg/d as the HPV used to calculate the various concentrations in fish corresponding to the protocol's meal frequencies found above in Table 4.2 for women of child-bearing age and children under 15. In adopting the Reference Dose as the HPV, the IFCMP reasoned that the thorough review of the toxicity database for methylmercury by the National Academy of Sciences, which formed the basis for U.S. EPA's Reference Dose, provided an adequate justification for using the Reference Dose until the Great Lakes states could develop an HPV for use with the Protocol. Since the Reference Dose was derived specifically to protect the developing nervous system of the fetus and children, the IFCMP has specified that the meal advice developed from it pertains to women of childbearing age and children less than 15 years old. It should be noted that the Great Lakes states have since adopted the Reference Dose as the HPV for methylmercury in the protocol.

The IFCMP operates under a Memorandum of Agreement (MOA), last renewed in 1989, that spells out many details of the responsibilities of the participating agencies (Illinois Departments of Agriculture, Natural Resources, Emergency Management Agency, Public Health and Illinois EPA). However, certain procedures and criteria for the determination and issuance of consumption advisories are now outdated or not specified in the MOA, leaving these elements to the discretion of the agencies. To address this, the IFCMP now closely follows the procedures recommended in the Great Lakes Protocol, and has adopted as policy over the years certain other procedures that replace outdated procedures in the MOA or are not specifically addressed by the MOA for the determination of advisories. Key elements of the procedures and policies for issuing the advisories include:

- The MOA lays out various tasks for the member agencies that allow the IFCMP to collect, process, analyze, and preserve for possible future analysis sufficient numbers and sizes of sport fish samples from across the State to evaluate levels of contaminants in most bodies of water accessible to anglers. The goal of the IFCMP is to sample most accessible waters every five to ten years, except for waters already under an advisory. In these cases, more frequent sampling is used to assess whether changes in the advisory are needed.

- The MOA specifies the collection of filet and whole fish samples from a network of 73 permanent stations for annual or biennial monitoring of trends in contaminant levels over time, plus additional samples from across the State to evaluate important sport-fishing waters. However, the funding source for trend monitoring has since been lost, and the existing funding at this time is dedicated to the analysis of filet samples for advisory purposes. Therefore, since 1993 only filet samples are analyzed and the permanent monitoring stations are sampled at the same frequency as similar stations across the State.

- The MOA specifies collection of a core set of samples from each body of water to be evaluated. These samples are to be composites of filets from 3-5 fish of similar size, and are to include two different sizes of bottom-feeders (preferably carp), one sample of an omnivorous species (preferably channel catfish), and one sample of a predatory species (preferably largemouth or smallmouth bass). These samples are analyzed for a suite of 14 bioaccumulative organic chemicals and mercury. If a sample is found to contain one or more of the analyses above a criterion, the IFCMP has adopted a policy of requiring a second set of samples from the water, which should include two bottom-feeders, two omnivores, two predators, and one or more additional species of local importance to confirm the original findings and provide sufficient data for the issuance of advisories if needed.

- The MOA specifies the use of the U.S. Food & Drug Administration's Action Levels as criteria for determining the need for advisories. However, the risk-based process developed in the *Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory* has been used to replace these criteria for mercury (Table 4.3). The protocol requires the determination of a Health Protection Value (HPV) for a contaminant, which is then used with five assumed meal consumption frequencies (8 ounces of uncooked filet): Unlimited (140 meals/year); One meal/week (52 meals/year); One meal/month (12 meals/year); One meal/two months (6 meals/year); and Do not eat (0 meals/year), to calculate the level of contaminant in fish that will not result in exceeding the HPV at the specified consumption frequency. The HPVs, target populations and critical health effects to be protected by the HPVs, and new criteria for these three chemicals for the various meal frequencies specified in the Protocol are listed in Table 4.3.

- The protocol stresses the benefits of fish consumption. Language relaying this message is included with all consumption advisories issued.

- The IFCMP has adopted a policy that, except in extraordinary circumstances, two or more recent sampling events in a water body finding fish exceeding a level of concern for one or more contaminants are necessary for issuing or changing an advisory. Similarly, two or more recent samples finding no fish exceeding criteria are necessary for rescinding an advisory.

**Table 4.3. Health Protection Values (HPVs) and Criteria Levels For Sport Fish Consumption Advisories For Methylmercury.**

| CHEMICAL | HPV (ug/kg/d) | TARGET POPULATION, EFFECT | MEAL FREQUENCY | CRITERIA LEVELS (mg/kg) |
|---|---|---|---|---|
| Methylmercury | 0.1 | Sensitive* Reproductive Developmental effects | Unlimited<br>1 meal/week<br>1 meal/month<br>1 meal/2months<br>Do not eat | 0-0.05<br>0.06-0.22<br>0.23-0.95<br>0.96-1.9<br>>1.9 |
| Methylmercury | 0.3 | Non-sensitive*, Nervous system effects | Unlimited<br>1 meal/week<br>1 meal/month<br>1 meal/2months<br>Do not eat | 0-0.15<br>0.16-0.65<br>0.66-2.8<br>2.9-5.6<br>>5.6 |

= Sensitive Population includes pregnant or nursing women, women of childbearing age, and children under 15; Non-sensitive Population includes women beyond childbearing age and men over 15.

### 4.2.2 Assessment of Fish Consumption Advisories

The assessment of whether a waterbody is supporting the fish consumption use is based on the presence or absence of fish consumption advisories, as noted in Table 4.4. If it is determined that a waterbody is "not supporting" the fish consumption use, then that waterbody is identified as impaired and is placed on the 303(d) list.

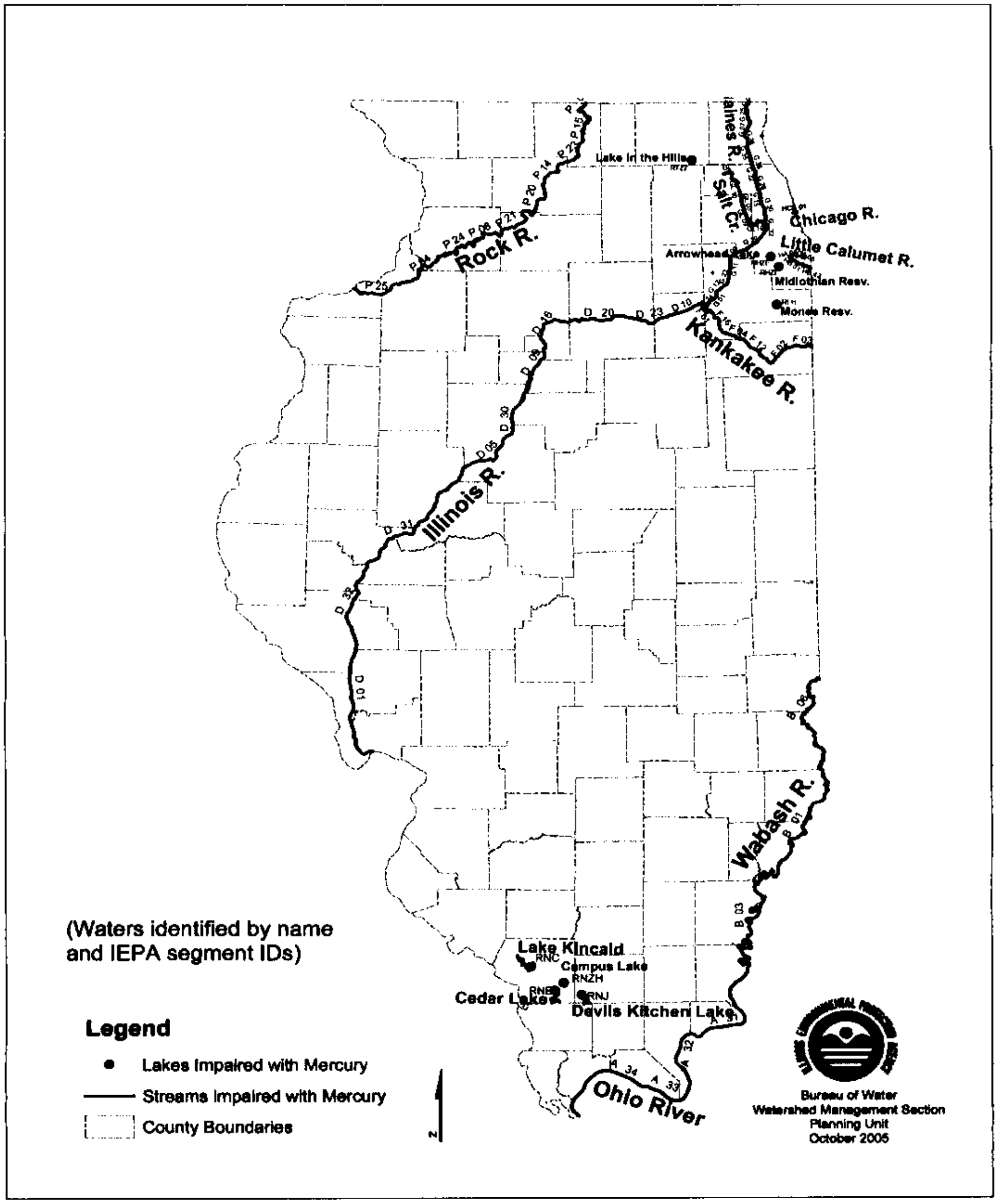
**Table 4.4. Guidelines for Assessing *Fish Consumption* Use in Illinois Streams, Inland Lakes, and Lake Michigan-Basin Waters Degree of Use Support Guidelines**

| Degree of Use Support | Guidelines |
|---|---|
| Fully Supporting (Good) | No waterbody-specific fish consumption advisory in effect |
| Not Supporting (Fair) | A "restricted consumption" advisory is in effect for the general human population or a subpopulation potentially at greater risk (e.g., pregnant women, children). Restricted consumption is defined as limits on the number of meals or size of meals consumed per unit time for one or more fish species. In Illinois, "restricted consumption" advisories are: 1 meal/week, 1 meal/month, or 6 meals/year. |
| Not Supporting (Poor) | A "no consumption" (i.e., "Do Not Eat") fish consumption advisory, for at least one fish species, is in effect for the general human population, or a commercial fishing ban is in effect. |

### 4.2.3 Waters in Illinois Currently Impaired for Fish Consumption Use Due to Mercury

When fish in a particular lake, river or stream are not safe for unlimited consumption because of mercury, a state is obligated to list that waterbody as impaired due to the requirements of Section 303(d) of the federal Clean Water Act and develop a TMDL to address the issue. According to the latest (2004) Illinois list of impaired waters, there are 61 river segments (1,034 miles) and 8 lakes (6,264 acres) that have mercury listed as a potential cause of impairment due to restrictions on fish consumption.

**Figure 4.1. Mercury Impaired Waters in the 2004 303(d) List**




The listing of a number of Illinois rivers and lakes as being impaired for fish consumption use due to mercury triggers a requirement that the state develop a TMDL to address the impairment. As discussed previously, Illinois EPA will need to determine what is the maximum amount of mercury loading from point sources and from nonpoint sources (with consideration of a margin of safety and seasonal variation) that can be introduced into the impaired rivers and lakes and still prevent mercury accumulation in fish tissue to unsafe levels.

Mercury TMDLs are complicated. The mechanisms controlling mercury accumulation in fish tissue are variable and difficult to model, resulting in questionable results. Finally, state water programs are challenged in addressing atmospheric loading of mercury, which has been shown to be a dominant contributor to many waters, because the sources may be outside the watershed, state or nation.

In view of the difficulty in producing useful TMDLs, the Environmental Council of States (ECOS) urged U.S. EPA in 2004 to adopt a national strategy to reduce mercury inputs to the environment (air, land and water) to the greatest extent possible. States recognized that putting resources into reducing the mercury problem would be more useful than spending them on a TMDL study to assure that every ounce of mercury loading was appropriately allocated.

### 4.3 Reductions in Fish Tissue Mercury Levels Needed to Address Impairment

In order to establish a "target" for what amount of reduction in fish tissue levels of mercury would be needed to get below fish consumption advisory levels and address this use impairment, Illinois EPA conducted an analysis of data from Illinois' ongoing fish contaminant monitoring program.

#### 4.3.1 Description of Data

There are a total of 815 samples for mercury concentrations in fish tissue for all waters in Illinois for samples collected between May 17, 1985 and November 11, 2004 (*see Appendix A: Illinois EPA, Bureau of Water, "Illinois 2004 Section 303(d) List," November 2004*). Each sample is associated with information on sampling location (Station code, stream/lake name, county name, and site description), sampling date (day, month, and year), fish species, number of individuals in the sample, average weight (in pounds) and length (in inches) of the individual in the sample, mercury concentration (mg/kg) in fish tissue, mercury detection level (mg/kg) and lipid content (percent). Data are also recorded on whether a whole fish or fish fillet was used in analysis for mercury concentration.

Largemouth bass (LMB) data from 397 samples were selected from this dataset and evaluated for purposes of this report. LMB are a top predator in all waters of the state and represent a large subset of all fish tissue data. Mercury content in all LMB in this dataset was determined for several statistical endpoints (mean, median, percentiles, standard deviation, etc.). We selected the target concentration for mercury at the $95^{th}$ percentile of the LMB data and calculated the necessary reduction in mercury needed to achieve 0.05 mg/kg, the highest acceptable level of mercury in fish tissue for unlimited consumption (i.e., the percent reduction needed to guarantee that 95% of all largemouth bass can be eaten in unlimited quantities).

### 4.3.2 Analysis

Largemouth bass, *Micropterus salmoides* (Lacepede), data from 397 samples were selected from the large set of data for all fish collected and analyzed for contaminant concentrations in Illinois. LMB were collected between May 1985 and May 2004 and are based on analysis of fillet samples. LMB are top predators and it is for this reason that the IFCMP targets LMB and two other bass species (smallmouth and spotted) as the primary indicators of contaminant presence prior to collecting fish tissue from other species. The LMB samples collected for fish tissue analysis constitute a significant part (48.7%) of the samples collected for all species.

LMB are widely distributed in Illinois waters and are tolerant of ecological conditions (Smith). In regard to the uptake of mercury, the young feed on plankton, while later life-stages feed on insects, crustaceans and fish (Smith; Jenkins and Burkhead). LMB are reputed to be the most important species of black bass in 42 states and the most important game fish in 11 (Jenkins and Burkhead).

Table 4.5 shows the results for various calculations for mercury concentrations in LMB based on the IFCMP dataset. The minimum concentration (0.10 mg/kg) represents the limit of detection for mercury analysis in fish tissue. To account for potential mercury concentrations in fillets lower than the level of detection, additional calculations were made based on an adjusted lower limit equal to half the detection limit (0.05 mg/kg), also shown in Table 4.5. Beginning in 2005, Illinois EPA modified the mercury analytical procedure to achieve a lower detection limit of approximately 0.01 mg/kg. These lower detection limit values were not adjusted to 0.05mg/kg. Of the 397 fish tissue samples in this database, 141 (35.5%) were reported at or below the detection limit applicable at that time.

**Table 4.5. Mercury Concentrations in Largemouth Bass in Illinois (mg/kg).**

| | **All LMB (n = 397) Detection Limit = 0.10** | **All LMB (n = 397) Detection Limit = 0.05** |
|---|---|---|
| Average | 0.1893 | 0.1723 |
| Maximum | 1.4 | 1.4 |
| Median | 0.12 | 0.12 |
| Minimum | 0.01 | 0.01 |
| $95^{th}$ Percentile | 0.544 | 0.523 |
| $25^{th}$ Percentile | 0.1 | 0.05 |
| Standard deviation | 0.1783 | 0.1840 |

We selected the target concentration for mercury in LMB tissue at the $95^{th}$ percentile of the LMB data and calculated the necessary reduction in mercury needed to achieve 0.05 mg/kg, the highest acceptable level of mercury in fish tissue for unlimited consumption. This level of protection provides the reduction needed to guarantee that 95% of all largemouth bass can be eaten in unlimited quantities by even the most sensitive sub-population (i.e., women of child-bearing age and children under 15 years old). At this level of protection, fish consumption would no longer be an impaired use, currently impaired waters would not be identified in under Section 303(d) as such and the need to develop mercury TMDLs will have been eliminated. The results for load reduction scenarios are shown in Table 4.6.

**Table 4.6. Mercury Reductions needed to attain unlimited consumption (mg/kg, unless otherwise shown).**

| | All LMB (n = 397) Detection Limit = 0.10 | All LMB (n = 397) Detection Limit = 0.05 |
|---|---|---|
| $95^{th}$ Percentile | 0.544 | 0.523 |
| Reduction needed | 0.494 | 0.473 |
| Percent reduction | 90.8% | 90.4% |

The reduction required for unlimited consumption by childbearing age women and children under 15 years of age, the most sensitive and restrictive sub-population, is about 90%.

## 4.4 Inputs of Mercury to Illinois Waters

Where does mercury come from and how does it get into the fish in Illinois waters? As in other parts of the United States, it is presumed that the mercury comes from natural and man-made sources. The man-made sources can directly discharge into waters or can release emissions into the air. Atmospheric deposition of mercury can come from local, regional and global emission sources.

### 4.4.1 Fate of Mercury in the Environment

The following discussion, reprinted from Section 2.4 of the Michigan Mercury Report (June, 2005), provides the basic information on the mercury cycle.

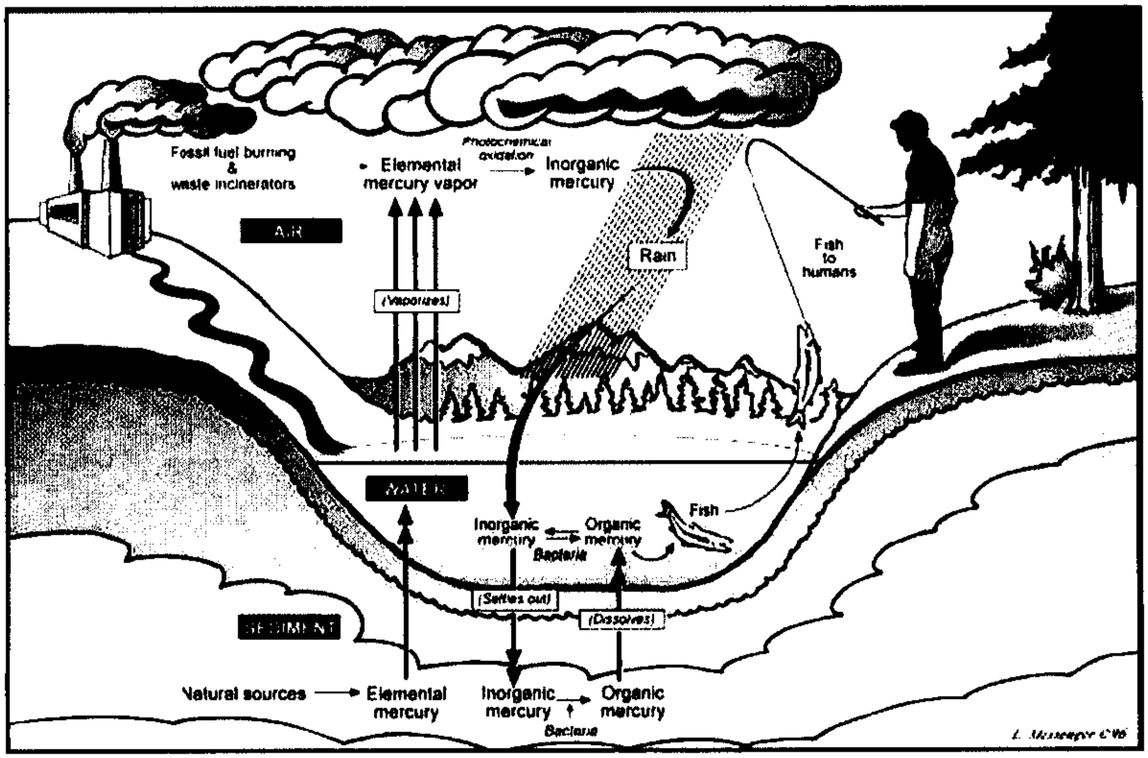
> The mercury cycle is quite complex. Mercury is released into the atmosphere from anthropogenic emissions as either a gas or attached to particles and is transferred to the earth's surface via wet or dry deposition or gas transfer. Mercury is emitted to the atmosphere in three basic forms: elemental mercury: ($Hg^0$); reactive gaseous mercury or RGM (RGM is also known as Hg(II) and oxidized gaseous mercury); and particulate mercury [Hg(p)]. (NOTE: These three abbreviations for mercury [$Hg^0$, RGM, and Hg(p)] will be utilized

throughout the remainder of this document.) Natural emissions are mainly in $Hg^0$ form. $Hg^0$ may reside in the atmosphere for up to one year, allowing global circulation systems to transport $Hg^0$ releases from the source to anywhere on earth before transformation and deposition take place. Figure 4.2 shows the mercury cycle.

Mercury is continuously mobilized, deposited, and re-mobilized in the environment. The only means to permanently capture mercury from the biosphere include deep- sea sediments, well-controlled landfills or amalgamation processes. For example, to isolate mercury from the biosphere, Sweden has recommended that mercury waste be stabilized and stored in a permanent deep bedrock repository (Swedish EPA, 2001).

The majority of mercury in surface soil is in the form of oxidized mercury compounds, such as mercuric sulfide. However, a small fraction is methylmercury and $Hg^0$. Mercury complexes deposited in soils can be transformed back into gaseous mercury by light and humic substances and re-enter the atmosphere. Mercury can also be taken up by plants, both via root uptake in soils and through absorption of elemental or inorganic mercury through the air.

**Figure 4.2: Mercury Cycle**




As part of a whole-ecosystem mercury cycling study, mercury was measured in the foliage of deciduous trees in Pellston, Michigan over the course of the growing season (Rea et al., 2002). This study found that total foliar mercury accumulation was substantially less than vapor phase $Hg_0$ deposition as estimated by a different study (Lindberg et al., 1992). It was determined that Hg(p) and RGM dry deposition were rapidly washed off foliar surfaces, and therefore foliar accumulation of mercury most likely represents vapor phase $Hg_0$ assimilation (Rea et al., 2001). Recently, independently performed controlled pot and chamber studies with aspen trees determined that all foliar accumulation of mercury was due to vapor uptake, regardless of soil mercury concentration (Ericksen et al,. 2003), supporting the Rea 2001 study conclusions. In addition, monitoring of mercury has been done through the use of mosses and lichens, including near industrial facilities (Lodenius, 1994).

In addition to direct deposition, mercury can also reach water from soil run-off, although the amount partitioning to run-off is expected to be small since mercury binds to soil. Mercury in run-off is probably bound to suspended sediments. Once in water, mercury can either enter and biomagnifying in the food chain, settle into sediment, or volatilize back into the atmosphere (see previous Figure 4.2). Entrance into the food chain begins with bacteria in water, which can take mercury in its inorganic form and metabolize it to methylmercury. All inorganic forms of mercury that are not bound to sediment are potentially available for methylation by microorganisms. A number of factors effect the potential for methylation of mercury in aquatic systems, but key variables are the potential of hydrogen ([pH] – a measurement of a solution), the oxidizing state (i.e., redox conditions), the levels of sulfur, and the presence of sulfate-reducing bacteria (Ullrich et al., 2001).

Methylmercury-containing bacteria may be consumed by the next level in the food chain, or the bacteria may excrete methylmercury into the water where it can adsorb to plankton and be consumed by the next level in the food chain and so on. Even small environmental concentrations of mercury in water can readily accumulate to potentially harmful concentrations in fish and fish-eating animals, including humans.

The concentration of methylmercury in predatory fish such as largemouth bass or walleye can be 1 to 10 million times higher than the surrounding surface water as a result of biomagnification (Ullrich et al., 2001). In general, fish higher in the food chain such as walleye, pike, shark and swordfish have higher mercury concentrations than fish lower on the food chain like perch. The ratios of methylmercury in fish can vary depending on fish age, size and species as well as watershed characteristics.

### 4.4.2 Loading of Mercury to Illinois Waters from Wastewater Discharges

In order to evaluate the loading of mercury, particularly to impaired waters, Illinois EPA conducted an analysis of existing Agency data. Discharge monitoring results from regulated point sources (NPDES permit holders) for the period of September 1986 through July 2005 was obtained from Illinois EPA Permit Compliance System (PCS). Of the 195 point sources identified as contributors of Hg to the Illinois surface waters, 18 point sources had permit effluent limits for Hg and 177 were required only to monitor the concentrations of Hg in their effluent. Further, Hg concentrations in the effluent were reported above detection limits (ADL) by 137 facilities and below detection limits (BDL) by 58 facilities. For a summary of pertinent information about point sources and concentration of mercury in their effluents see *Appendix B of the Illinois 2004 Section 303(d) List* (Illinois EPA, "Illinois 2004 Section 303(d) List," November 2004).

Of the 137 facilities with ADL mercury concentrations, 89 facilities fell in six major watersheds, which contained waterbodies listed as potentially impaired due to mercury in the 2004 303(d) report. The remaining 48 facilities were in the watersheds that did not contain any waterbody potentially impaired due to mercury. Table 4.7 shows mercury data for some of the major river basins in Illinois, based on the reported average and maximum effluent discharges. Pertinent information on how mercury loads from point sources were calculated is in *Appendix C of the Illinois 2004 Section 303(d) List* (Illinois EPA, "Illinois 2004 Section 303(d) List," November 2004).

**Table 4.7. Mercury Loads for Selected Watersheds with Impaired Segments, 1986-2005.**

| Watershed Name | # of Facilities with ADL | Average Load (tons/year) | Maximum* Load (tons/year) |
|---|---|---|---|
| Rock River | 10 | 0.0002609 | 0.0172808 |
| Des Plaines River | 28 | 0.0013262 | 0.4855664 |
| Fox River | 14 | 0.000311 | 0.018718965 |
| Illinois River | 26 | 0.0112418 | 0.659966246 |
| Wabash River | 8 | 0.0002672 | 0.0232629 |
| Ohio River | 3 | 0.000168 | 0.0199586 |
| Sub-Total | 89 | 0.0134071 | 1.2247538 |
| Others** | 48 | 0.0088908 | 0.2652383 |
| Total | 137 | 0.0222979 | 1.48999215 |

**ADL = Above detection limit**

= potential maximum
** = watersheds with ADL facilities but not on 2004 303(d) List Load (tons/years)

The lowest (0.0000005 mg/L) and highest (33.7 mg/L),( probably an outlier) concentrations of mercury were found in the effluent of Cordova Energy Company (IL0074438) in March 2003 and 2004 and Deerfield WRF (IL0028347) in May 2005, respectively. After eliminating potential outliers from consideration, it was determined that on a statewide basis, the contribution of mercury from all point sources to surface waters on an average was 0.02229791 tons (44.5958 pounds) per year. This average contribution includes, in some cases, the average value of daily maximum concentration of mercury in the effluent of point source due to unavailability of 30-day average concentration values.

The statewide average of all point source discharges of mercury (0.02229791 ton per year) was only 0.745 % of the base year total emissions of mercury (2.99466 tons per year) in Illinois.

In summary, wastewater discharges to receiving streams and rivers in Illinois provide an average annual loading of 45 pounds of mercury per year. However, several of the lakes in Illinois that are listed for fish consumption impairment due to mercury, and have the highest fish tissue levels of mercury detected in the state, have no point source discharges at all.

### 4.4.3 Study of Mercury Concentrations in Ambient Water

In 2004, Illinois EPA sampled water from selected streams and lakes in Illinois. One goal of the study was to measure concentrations of total mercury in a subset of Illinois surface waters and compare the results to the Illinois human health-based water quality standard of 12 parts per trillion. Samples were collected from 52 stream locations and 32 lake locations spread geographically throughout the State as shown in the two maps below. The lakes sampled included several that are listed as impaired for fish consumption due to mercury. Sample collection was made using EPA Method 1699 and sample analysis by EPA Method 1631, the preferred methods for accurate low-level mercury measurement. A complete discussion of this study is provided in *Appendix D of Illinois 2004 Section 303(d)List (*Illinois EPA, "Illinois 2004 Section 303(d) List," November 2004).

**Figure 4.3**

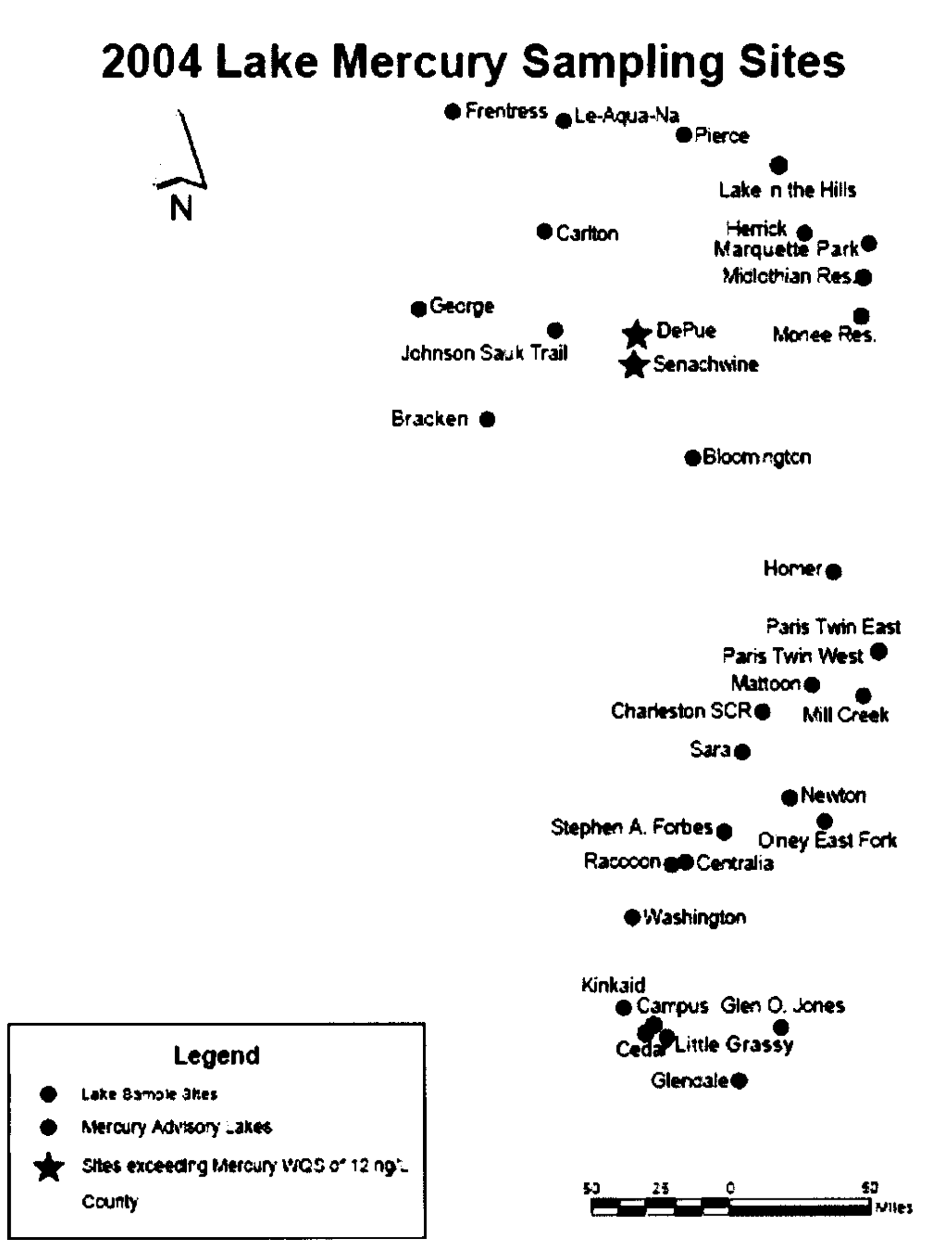
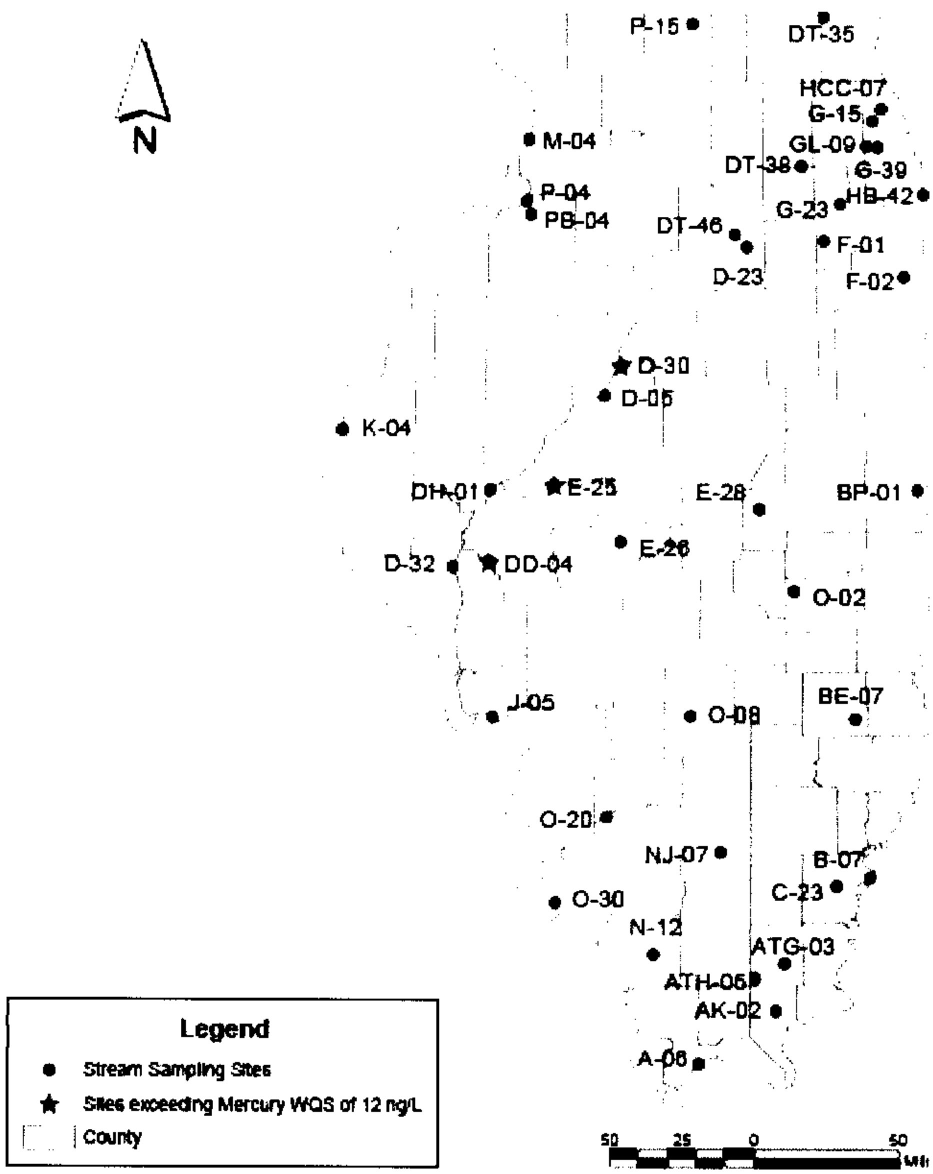

2004 Lake Mercury Sampling Sites
N
Frentress
Le-Aqua-Na
Pierce
Lake n the Hills
Carlton
Herrick
Marquette Park
Midlothian Res.
George
Johnson Sauk Trail
DePue
Senachwine
Monee Res.
Bracken
Bloomington
Homer
Paris Twin East
Paris Twin West
Mattoon
Charleston SCR
Mill Creek
Sara
Newton
Stephen A. Forbes
Olney East Fork
Raccoon
Centralia
Washington
Kinkaid
Campus
Glen O. Jones
Cedar
Little Grassy
Glendale
Legend
Lake Sample Sites
Mercury Advisory Lakes
Sites exceeding Mercury WQS of 12 ng/L
County
50
25
0
50
Miles

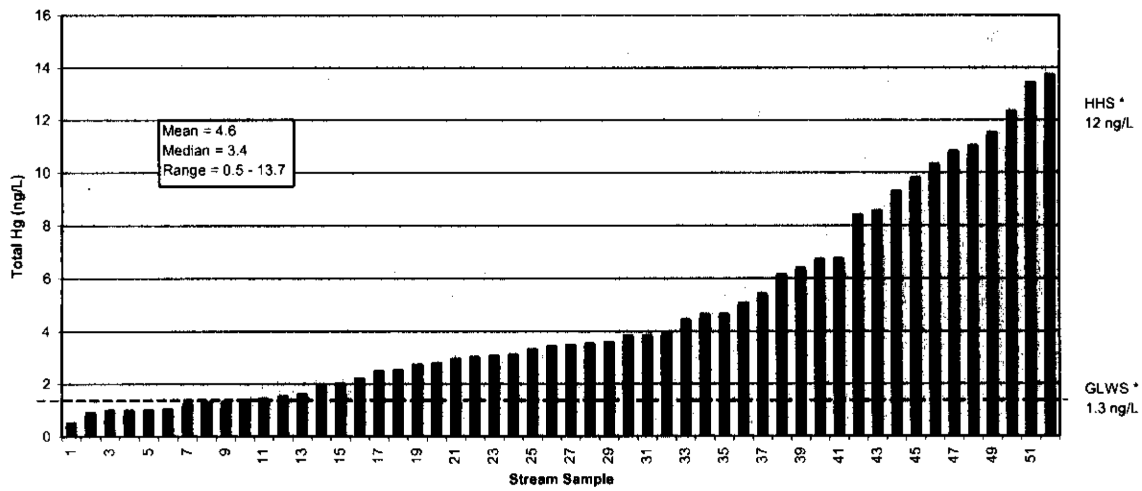
**Figure 4.4**

# 2004 Stream Mercury Sampling Sites



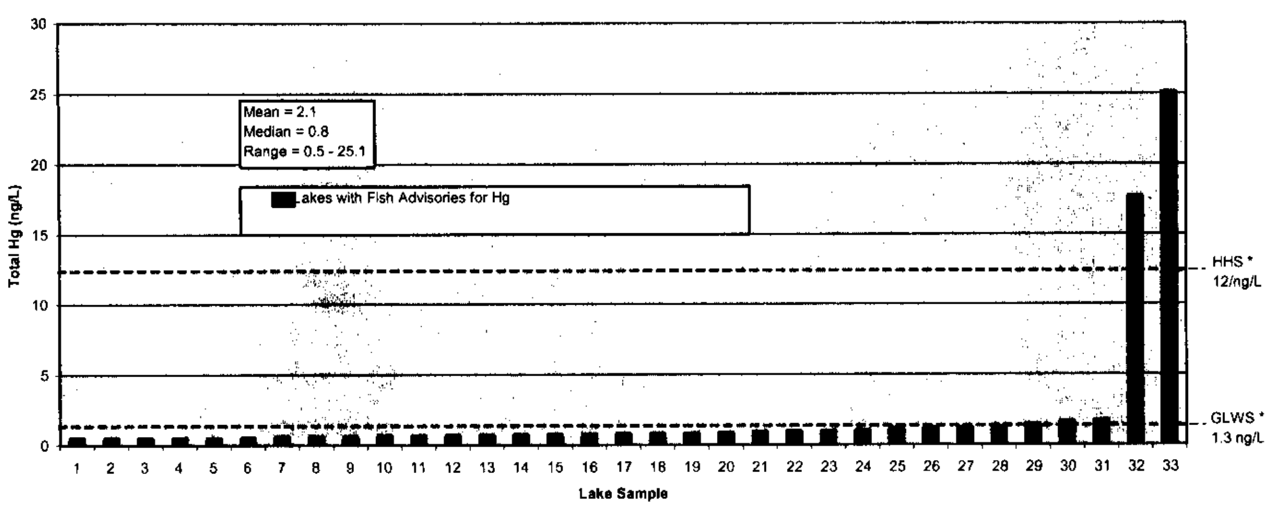
The results found concentrations of total mercury in most samples did not exceed the human health water quality standard of 12 parts per trillion (see Figure 4.5 and 4.6). Three of 52 stream samples and two of 32 lake samples exceeded the standard. Interestingly, the lakes where the ambient mercury levels were higher than the standard are not lakes with specific fish consumption advisories (i.e., not listed as impaired).

**Figure 4.5 Illinois Ambient Water Quality Monitoring Network Core Stream Samples, Mar-Oct 2004**




* HHS = human health standard; GLWS = Great Lakes Water Quality Standard

**Figure 4.6 Illinois Ambient Lakes Samples, Aug - Oct 2004**




* HHS = human health standard; GLWS = Great Lakes Water Quality Standard

## 4.5 Fish Consumption and At-Risk Anglers

Annually, Illinois anglers purchase over 700,000 fishing licenses. In order to answer the question of how these anglers and their families might be at risk of consuming chemical contaminants at levels greater than health-based limits in the fish they caught, Illinois EPA has reviewed several studies and reports of fish consumption by the general population and by sport anglers. Since the Illinois Department of Natural Resources and the Illinois Natural History Survey do not include questions regarding consumption of sport fish caught by anglers in their angler surveys, it was necessary to evaluate fish consumption rates by Illinois anglers in other ways in order to evaluate at-risk anglers. An in-depth report of fish consumption in California and in the United States by the California EPA (2001) has been valuable in our evaluation.

National Surveys – Several national surveys have been conducted to evaluate fish and shellfish consumption by the general public. It must be kept in mind that these surveys were conducted for different purposes over different time frames, using different methodologies. Nevertheless, California EPA (2001) reports that the range of national per capita fish and shellfish consumption rates is very consistent among studies considered to be valid, from 10 grams per day (g/d) to 17.9 g/d or approximately 16-28 eight-ounce meals per year *(See attached Table 2 from California EPA, 2001).*

It should be noted that surveys of the general population contain persons who eat no fish. A few of these surveys also contain information on respondents that had consumed fish during the survey period. These "consumers only" data can provide a more reasonable estimate of fish and shellfish consumption by persons who eat seafood. For example, Pao et al. (1982) evaluated the "consumers only" data from the 1977-1978 USDA Nationwide Food Consumption Survey (NFCS) (USDA, 1983), and found that the mean overall fish and shellfish consumption rate for consumers was 48 g/d, or approximately 77 eight-ounce meals/year, versus the rate for the general population from the NFCS of 12 g/d (19 meals/yr). Another study by Popkin et al. (1989) provides additional data that may be particularly relevant to evaluating potential risks due to seafood consumption. This study reviewed data for female "consumers only" of childbearing age (ages 19-50) from both the NFCS and the 1985-1986 USDA Continuing Survey of Food Intake by Individuals (CSFII) (USDA, 1987; USDA 1988). This study found that these female consumers reported an average consumption of fish and shellfish of 111 g/d (approximately 178 meals/year) from the NFCS data and 88.2 g/d (141 meals/year) from the CSFII data.

Surveys of Consumers of Sport Fish – The literature regarding persons who eat sport-caught fish is limited in comparison to studies of the general population's consumption of all types of seafood. As is the case for the "consumers only" populations discussed above, anglers consume more seafood meals per year than the general population (see attached Table 6 from California EPA, 2001). This table shows that mean levels of fish consumption in these studies range from 12.3 to 63.2 g/d (approximately 19-101 eight-ounce meals/year). Most of these studies also provide high-end rates of sport fish consumption ($95^{th}$ or $96^{th}$ percentiles, or maximum reported), which range from 17.9 to 220 g/d (28-353 meals/year).

Studies of sport fish consumption by angler cohorts in Michigan and California provide the most thorough evaluations of consumers of sport fish. The studies of Michigan anglers (the Michigan Sport Anglers study; West et al., 1992, 1993, Murray and Burmaster, 1994) provide data for total amounts of fish and self-caught fish consumed by various sub-groups of the cohort (see attached Table 8 from California EPA, 2001). From the table, it can be seen that this group also consumes much more fish than the general population, with mean and $95^{th}$ percentile rates as high as 61.3 and 123.9 g/d (99 and 199 meals/year), respectively. Particularly relevant for describing at-risk populations are the information regarding females (ages not specified), with mean and $95^{th}$ percentile of total fish consumption reported to be 42.3 and 85.7 g/d (68 and 138 meals/year), respectively.

The studies of California anglers provide very similar results, although this study evaluated consumption of marine fish. These studies (the 1991-1992 Santa Monica Bay Seafood Consumption Study; SCCWRP and MBC, 1994, Allen, et al., 1996) reported an overall mean consumption rate by Bay anglers of 49.6 g/d (80 meals/year), which is consistent with the mean values for the Michigan anglers from Table 8. The Santa Monica Bay Study also includes data on various ethnic groups that demonstrate considerable variability; the $90^{th}$ percentiles ranged from a low of 64.3 g/d (103 meals/year) for Hispanics to a high of 173.6 g/d (279 meals/year) for "Other" (primarily Pacific Islanders) anglers.

Study of Illinois Lake Michigan Anglers – Using Illinois Natural History Survey data from creel surveys of anglers fishing the Illinois portion of Lake Michigan from 1987 to 1993, Pellettieri et al. (1996) evaluated the potential for these anglers to exceed the Health Protection Value (HPV) adopted by the Great Lakes states for daily intake of polychlorinated biphenyls (PCBs) of 3.5 micrograms per day (ug/d) as a result of their consumption of sport-caught fish from Lake Michigan. This study used data from Illinois and Wisconsin to determine PCB levels in five commonly caught species (yellow perch, brown and rainbow trout, and coho and Chinook salmon). These calculated PCB concentrations were then combined with the five meal consumption frequencies chosen by the Great Lakes states for issuing consumption advice (Unlimited = 225 meals/year; One meal/week = 52 meals/year; One meal/month = 12 meals/year; 6 meals/year; and Do not eat) to estimate anglers' intakes of PCBs for nine survey time periods covering spring, summer, and fall. The study found that if anglers consume their catch at the Unlimited rate, the acceptable daily PCB intake would be exceeded for all time periods (range of intakes 7.27 to 71.85 ug/d), and even consumption at the One meal/week rate would exceed the limit in four time periods (those periods when more highly contaminated salmon were most likely to be caught; range 1.67 to 16.60 ug/d).

Conclusions – Our review of fish consumption literature provides convincing evidence that sport anglers may consume amounts of sport-caught fish that could allow them and their families to exceed health-based limits for chemical contaminants in their catch. The literature regarding anglers' consumption of their catch strongly suggests that a subset of these anglers have meal frequencies that put them well above the recommended rates for even fairly low levels of contamination. For example, even the mean rates of consumption for sport-caught fish, in the range of 60-80 meals/year based on the Michigan and California studies, exceed the recommended meal frequency of one meal/week for lower levels of contamination. These consumption rates also exceed the Illinois Fish Contaminant Monitoring Program' s state-wide advisory for mercury, which recommends that women of child-bearing age and children under 15 limit their consumption of predator species to no more than one meal/week.

If anglers at the upper end of the meal frequency distribution are eating relatively contaminated fish, the risks to the anglers and their families are even greater. This is clearly illustrated by the upper percentile results noted above, with high-end consumers of sport fish eating 100 to 300+ meals/year. Such consumption rates would place these anglers and their families at risk from even low levels of contamination in their catch, and if contaminant levels are moderate or high the risks are correspondingly elevated. This is further demonstrated by the results from the Illinois Lake Michigan anglers, who were found to exceed recommended levels of PCB intake at the Unlimited meal frequency and even the one meal/week rate for some time periods. Thus, we can say with a high level of confidence that it is possible for anglers and their families to consume enough sport fish to put themselves and their families at risk from chemical contaminants in their catch.

## 5.0 Deposition of Mercury

### 5.1 Mercury in the Atmosphere

Mercury is emitted into the atmosphere by both natural and man-made, or anthropogenic, emission sources, and is then removed from the atmosphere by precipitation or dry deposition processes. Mercury can be transported hundreds, or thousands, of miles, or it can be deposited on the ground, on vegetatative surfaces, or into water-bodies downwind of emission sources.

The behavior of mercury in the atmosphere depends on its physical state, whether gaseous or particulate, and on its chemical speciation. Gaseous mercury exists as elemental mercury (Hg(0)), monovalent mercury (Hg(1)), or divalent mercury (Hg(2)). Elemental mercury in gaseous form is relatively insoluable, and is therefore less susceptible to wet deposition. As a result, elemental mercury can be transported great distances and is the most prevalent form of mercury in the atmosphere. In contrast, divalent mercury (Hg(2)) is soluble, combining readily with cloud droplets and precipitation. Hg(2) may also react with particles in a stack or in the atmosphere. Particle-borne mercury (Hg(p)) can be deposited on the ground by either wet or dry processes.

Although elemental mercury is less susceptible to wet or dry deposition, it can react, or oxidize, in the atmosphere under the right conditions, making it more readily available for deposition. The rate of conversion from Hg(0) to Hg(2) is not well understood. In a report prepared under contract to Illinois EPA (included as Appendix B) entitled: *"Atmospheric Deposition of*

*Mercury" (March 2006)*, Dr. Gerald Keeler of the University of Michigan describes the association of ambient ozone concentrations and the production of Hg(2) from Hg(0) in the Midwest. In his review of current studies, Keeler suggests that the lifetime of elemental mercury in the atmosphere is likely much shorter than previously believed. Thus, mercury may be deposited much closer to its source, even if emitted in elemental form, if oxidizing compounds are present in the atmosphere.

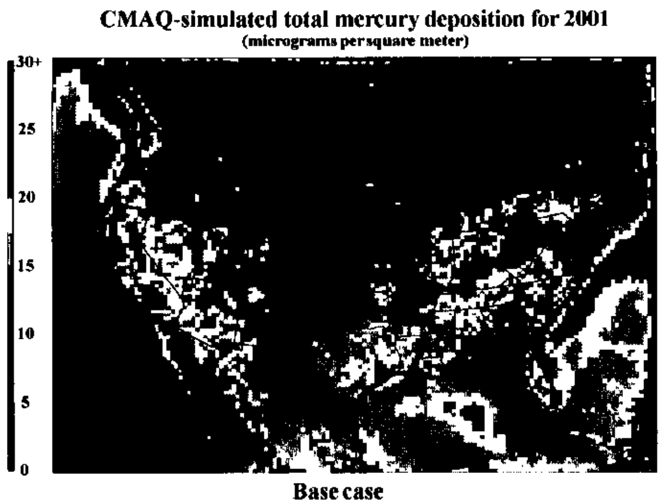
Keeler has summarized a number of ambient mercury measurement (i.e., monitoring) studies performed in the Midwest (*See* Appendix B). These studies include:

1. The Lake Michigan Urban Air Toxics Study (1991);
2. The Great Lakes Atmospheric Mercury Assessment Project (1994-1996);
3. The Lake Michigan Mass Balance Study(1994-1995); and
4. The Atmospheric Exchange Over Lakes and Oceans Study (1994-1995).

These studies document the importance of local sources of mercury emissions to mercury deposition in downwind locations. Significant gradients of mercury deposition downwind of high emission source regions were identified in these studies. Subsequent studies summarized by Keeler, including measurements in Detroit (2000-2002) and Steubenville, Ohio (2002) also demonstrate the significance of local and regional emission sources.

In the Utility Air Toxics Study report to Congress, U.S. EPA identified coal-fired power plants as the largest domestic anthropogenic source of mercury in the atmosphere. Various modeling techniques have been developed to evaluate the relative importance of coal-fired power plants and other emission sources. U.S. EPA used the Community Multi-Scale Air Quality model (CMAQ) to evaluate the effectiveness of the CAMR cap-and-trade program. CMAQ is a grid-based model that incorporates a detailed inventory of emission sources, both natural and man-made, to simulate the transport, dispersion, chemical transformation, and deposition of mercury in the atmosphere. At a recent "Mercury Workshop" sponsored by the Lake Michigan Air Directors Consortium (LADCO) (February 2006), U.S. EPA presented the results of their current CMAQ modeling simulations. These results are depicted in the following Figures 5.1 and 5.2.

## Figure 5.1
## CMAQ – Simulated Mercury Deposition For 2001, Base Case




## Figure 5.2
## CMAQ – Simulated Mercury Deposition For 2001, Utility Zero Out

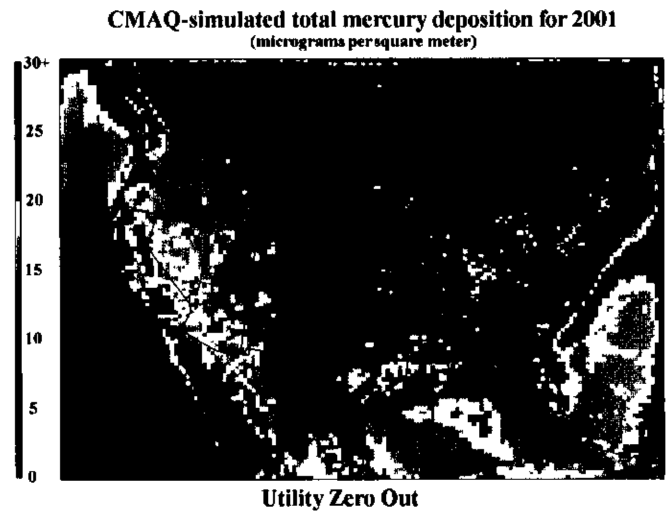


Figure 5.1 depicts modeled mercury deposition in the U.S. for the year 2001. The modeled results indicate relatively high mercury deposition on the West Coast and along the Ohio River valley, and relatively low deposition in the north-central U.S. Figure 5.2 depicts modeled deposition assuming zero emissions from coal-fired power plants. In this simulation, predicted deposition rates in the Ohio River valley are reduced dramatically, compared to the 2001 base scenario. From these results, U.S. EPA concluded that, on an overall basis, coal-fired power plants contribute less than 5% of the total deposition in the U.S., but locally the impacts of coal-fired power plants vary from as little as 0.05% to as much as 85.9%.

Grid-based models can be useful tools for evaluating source-receptor relationships, but because of uncertainties in model formulations and inputs, the results must be used with caution. These uncertainties include the scarcity of appropriate ambient measurements, especially measurements downwind of large emission sources and the lack of dry deposition measurements, the lack of speciated stack test data from coal-fired power plants and other significant emission sources, and uncertainties in simulating the effects of boundary conditions which are used to represent the contribution of sources outside the modeling domain.

In its comments to U.S. EPA's *"Revision of December 2000 Regulatory Finding on the Emissions of Hazardous Air Pollutants From Electric Utility Steam Generating Units"* (70 *Federal Register* 208, October 28, 2005), the Electric Power Research Institute (EPRI) presented modeling results using the Trace Element and Analysis Model (TEAM) and the Total Risk of Utility Emissions (TRUE) model. Both models were developed by EPRI. The TEAM model is a grid-based model (similar to U.S. EPA's CMAQ model), while the TRUE model uses the traditional Gaussian plume approach (similar to U.S. EPA's Industrial Source Complex (ISC) model). EPRI compared the results of these two models to evaluate whether grid-based models over-estimate mercury deposition. As mentioned above, grid-based models, including EPRI's TEAM model have inherent uncertainties, as mentioned above. In addition, traditional steady-state Gaussian models, although better suited for "close-to-the-source" ambient concentration predictions, also contain inherent uncertainties. Making model-to-model comparisons, as offered by EPRI may provide useful information, but may also compound the uncertainties. Again, the lack of adequate field monitoring, especially measurements of dry deposition of mercury, for comparison to and validation of modeled predictions limit the usefulness of the results.

Multi-variate statistical receptor models provide another useful means for evaluating the impacts of local and regional emission sources. Receptor models do not attempt to simulate complex transport and chemical processes, but rather rely on detailed ambient measurements at a specific location or receptor. Keeler summarizes the results of several studies that have used receptor modeling techniques. These studies document the importance of local and regional source contributions to mercury deposition in some locations. One of these studies, performed from ambient monitoring of mercury and other compounds in Steubenville, Ohio, indicated that coal-fired power plants contributed up to 70% of the wet deposition observed at that location.

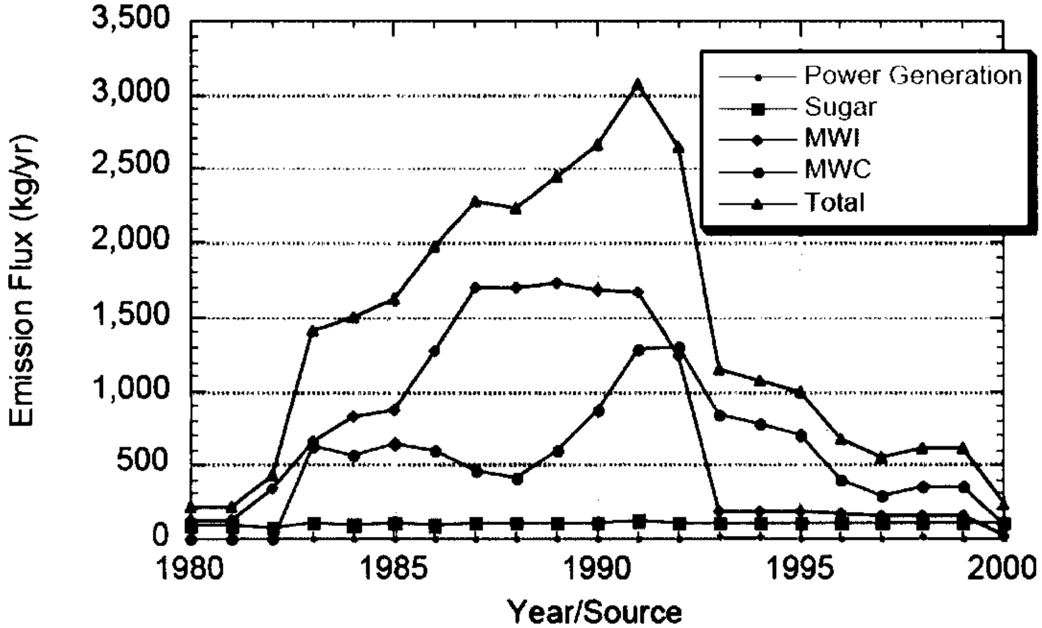
In summary, recent monitoring, modeling, and other research in recent years has led to an increased understanding of the sources of mercury, the chemical transformations that effect it, and the processes in the atmosphere that cause it to be deposited to the ground. Although many uncertainties remain and much research is still needed, the importance of anthropogenic sources, including coal-fired power plants, have been well documented. Thus, it can be expected that significant mercury emission reductions in Illinois will yield significant reductions of mercury deposition in Illinois.

## 5.2 Response of Fish Tissue Mercury Levels in Key Waterbodies in Florida and Massachusetts to Local Reductions in Mercury Emissions

### 5.2.1 Florida Experience

The State of Florida recognized in the late 1980s that mercury was a problem in the Everglades and it set about to resolve that problem. The first fish consumption advisories for the Everglades were issued in the l980s for largemouth bass. It was determined that atmospheric deposition of mercury was contributing 98% of mercury loading to the Everglades. Between state and federal requirements, a substantial reduction in mercury emissions occurred in the 1990s.

**Figure 5.3 Emissions of total Mercury by Major Source Category for Dade, Broward, and Palm Beach Counties**




Within a few years, measurements of mercury in egret feathers, tissue of largemouth bass and mosquitofish showed substantial declines.

**Figure 5.4 Mercury Concentrations in Feathers of Egrets**

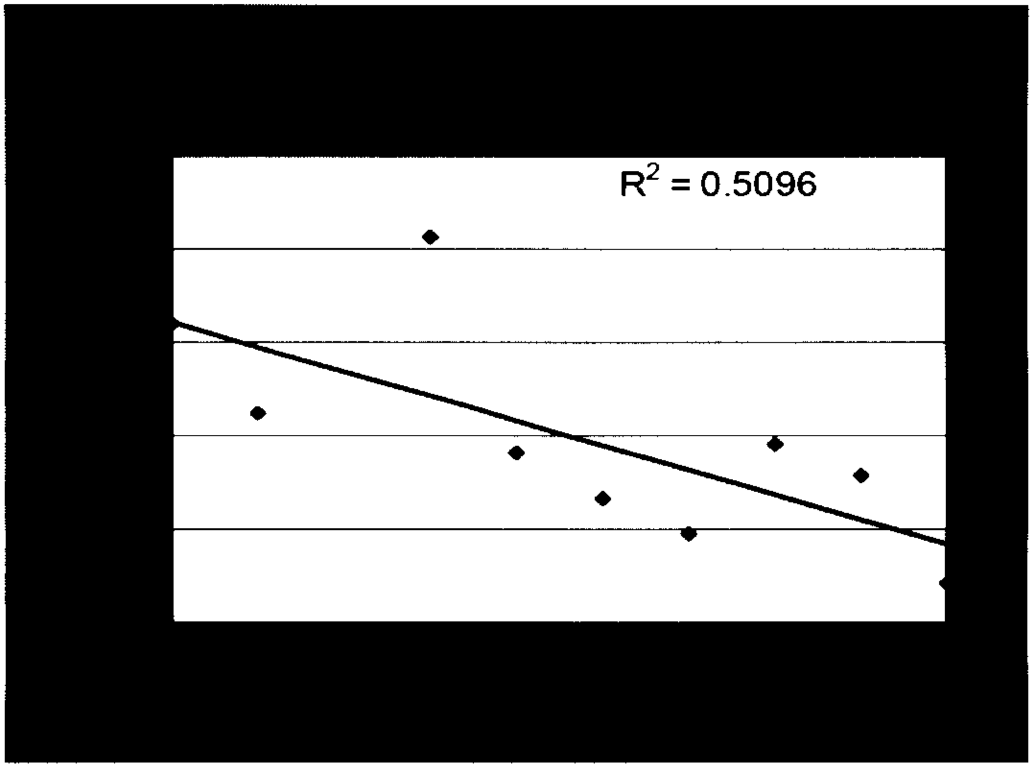
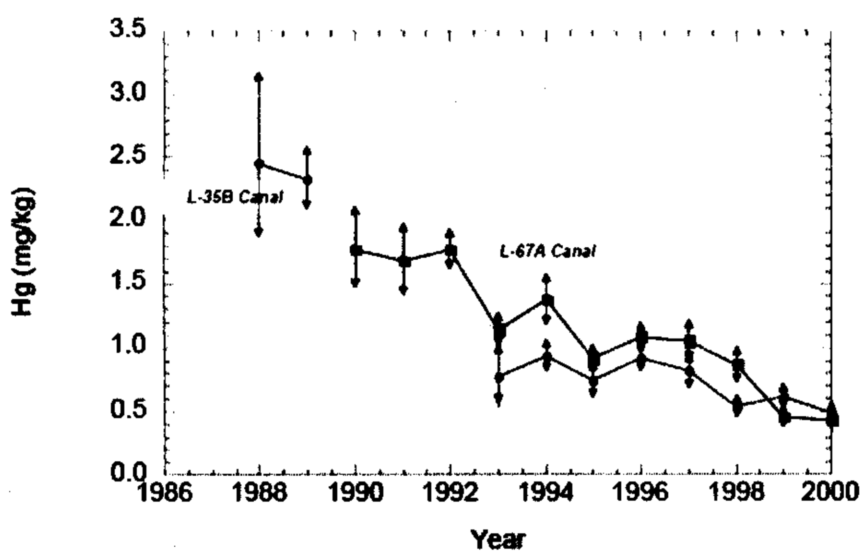
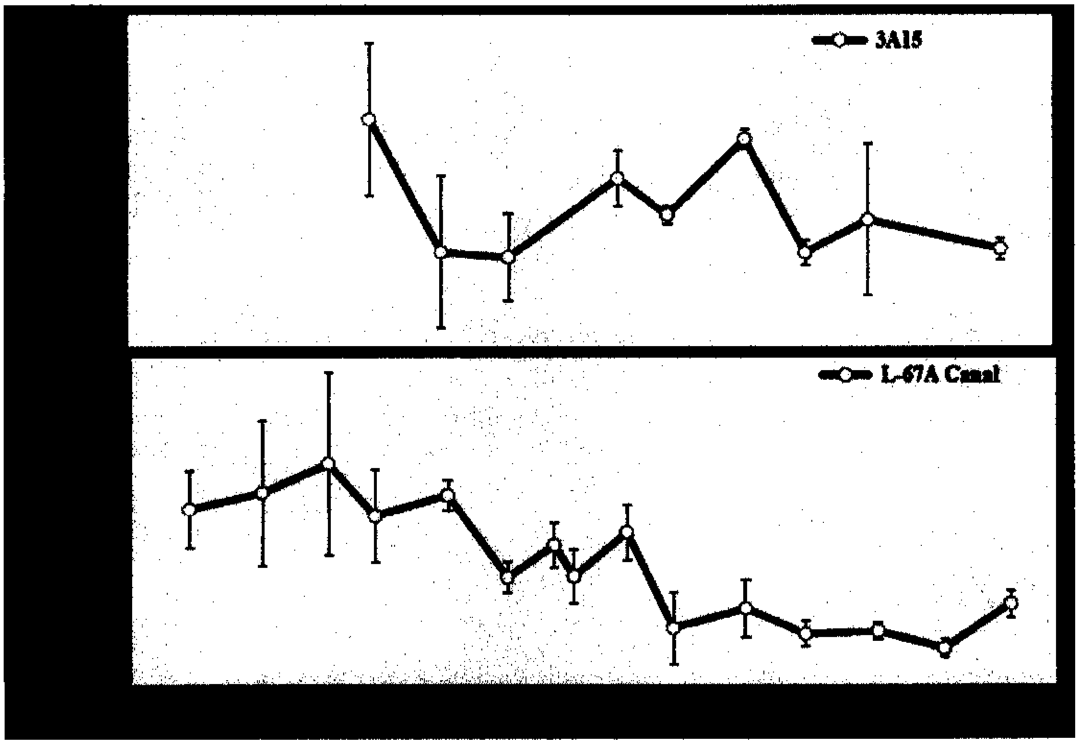



**Figure 5.5 Mercury Concentrations in Largemouth Bass Everglades Canals L-37B and L-67A Geometric mean by year. Diamonds show +1 SE of the Mean**



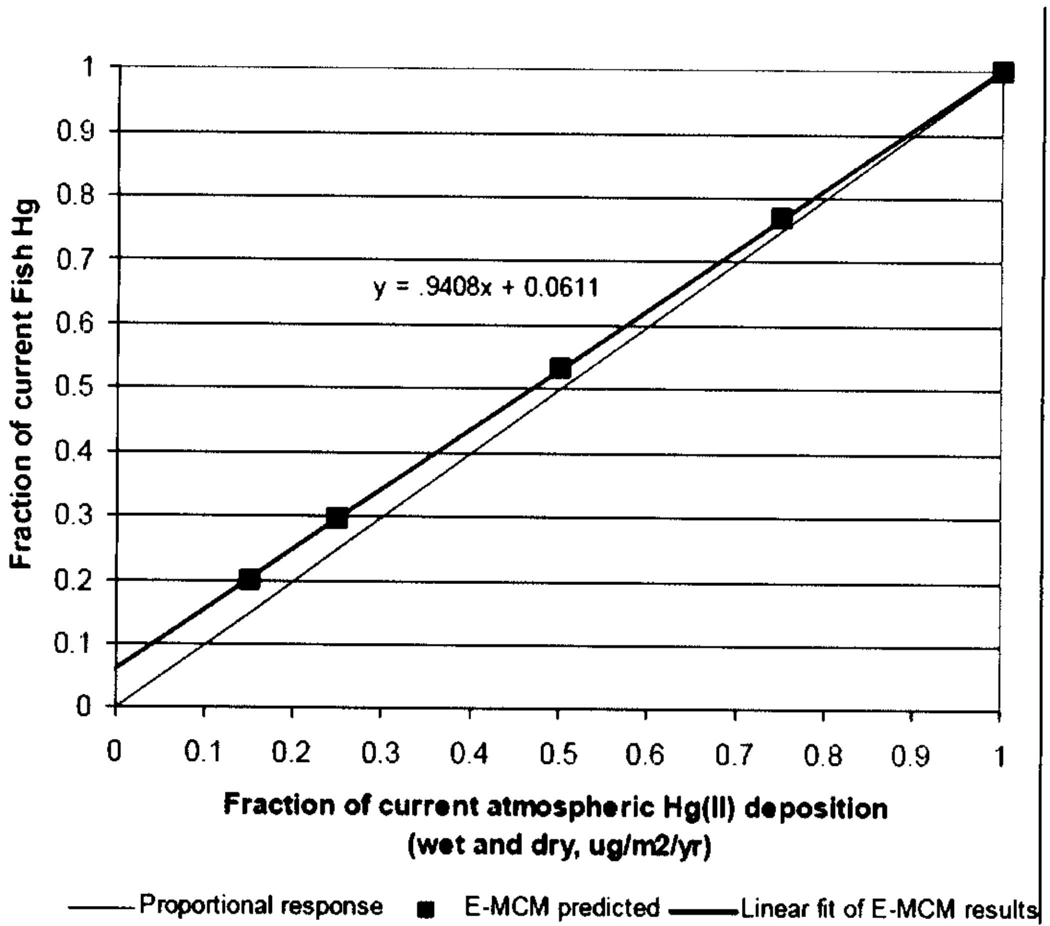

Data courtesy of Ted Lange, FWC.

**Figure 5.6 Largemouth Bass Hg Trends at Canal and Marsh Trend Monitoring Sites**




The relationship between mercury load to the Everglades and the body burden of 3-year-old largemouth bass has been modeled. Response is nearly 1 to 1.

**Figure 5.7 Relation between Atmospheric Mercury Load and Body Burden in Largemouth Bass**




From its experience over the last decade, Florida has concluded that reduction in local atmospheric emissions of mercury has led to >75% declines in the mercury in fish tissues and wildlife in less than 15 years since peak deposition. They have noted that reduction in emissions of mercury in the reactive gaseous form (RGM) will show benefits at the local or regional scale within years to decades. The main driver of the Everglades mercury problem is mercury load, overwhelmingly from atmospheric deposition. Interestingly, the reduction in mercury loading was significant, even in the presence of a substantial global mercury pool. Complete reports on Florida's work can be found at http://www.dep.state.fl.us/labs/mercury/

### 5.2.2 Massachusetts Experience

Like most states in the Eastern United States, Massachusetts has a statewide fish consumption advisory due to mercury. However, modeling and monitoring identified a deposition "hotspot" in northeastern Massachusetts. As part of a region-wide mercury action plan, Massachusetts has implemented extensive multi-media programs to reduce mercury inputs, including pollution prevention, requirements for management of waste dental amalgam and reduction of air emissions of mercury. Atmospheric deposition of mercury from fossil fuel combustion and medical waste incineration were identified as significant contributors of mercury loading to northeastern Massachusetts.

Medical waste incinerator controls were implemented in the late 1990s. As in the Florida experience, steep reductions in mercury emissions resulted in a similarly steep decline in fish tissue levels from the waters in northeastern Massachusetts within 5 years.

**Figure 5.8 Representative Fish Tissue Mercury and Incinerator Emissions Changes Versus Time in NE MA.**

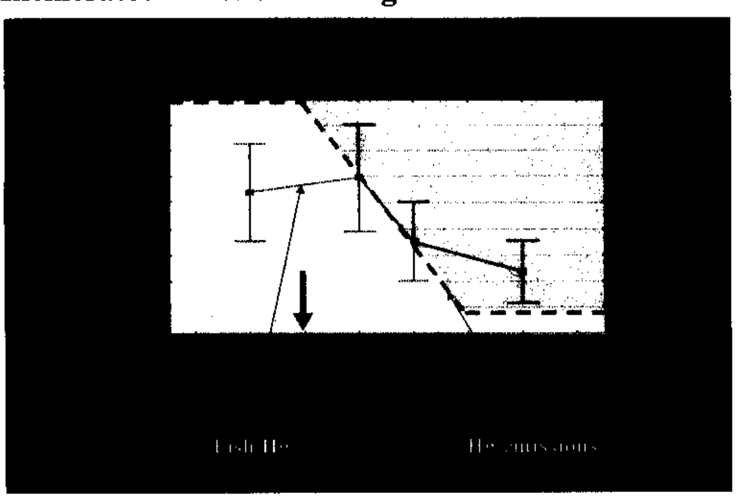
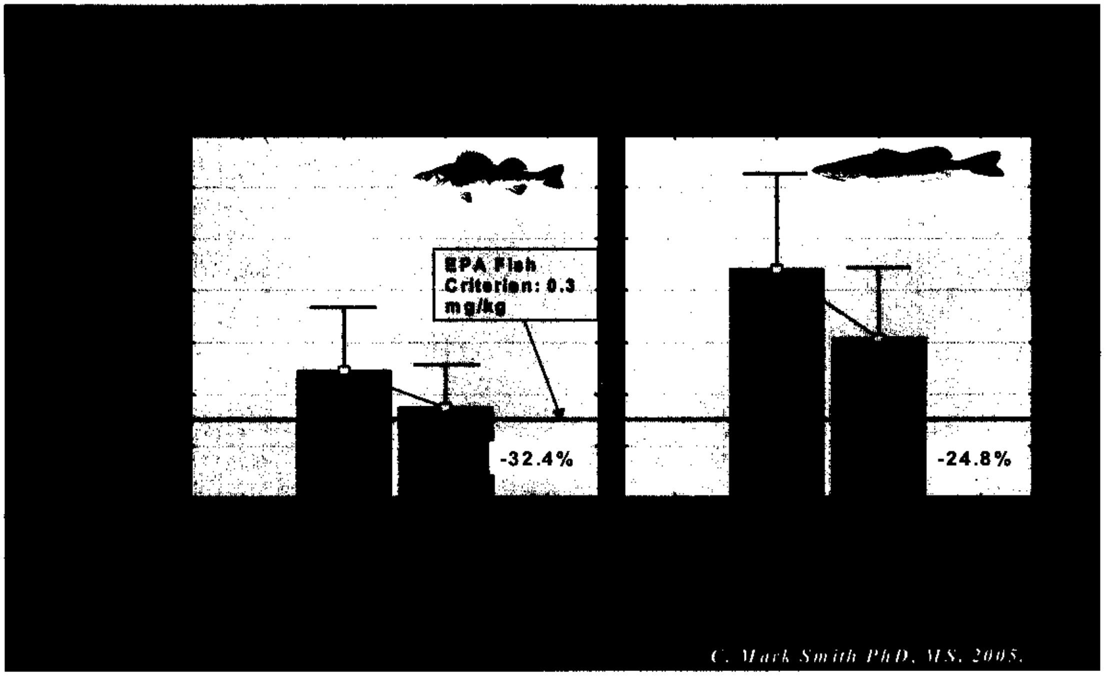


**Figure 5.9 Mercury Concentration in Yellow Perch and Largemouth Bass in 1999, 2004**




## 6.0 Regulatory Activities - Federal and Other States

### 6.1 Federal Actions

#### 6.1.1 Mercury Study Report to Congress

The Mercury Study is a report to Congress prepared by U.S. EPA to fullfill the requirements of section 112 (n)(1)(B) of the Clean Air Act, as amended in 1990. The Mercury Study provides an assessment of the magnitude of mercury emissions from power plants and other industrial sources, the health and environmental impacts of those emissions, and the availability and cost of control technologies. These findings provide a snapshot of U.S. EPA's understanding of mercury when the Mercury Study was issued in December 1997. (http://www.epa.gov/mercury/report.htm)

#### 6.1.2 Utility Electric Generating Units Toxics Study

Under the Clean Air Act, as amended in 1990, U.S. EPA was required to conduct a study of the public health impacts of emissions of air toxics from electric generating utilities that burn fossil fuels. Emissions from utilities include 67 air toxics, including arsenic, nickel, chromium, radionuclides and mercury.

The Utility Air Toxics Study issued in February 1998 evaluated electric generating utilities that burn coal, oil, or gas to generate electricity and are greater than 25 megawatts in size. The Utility Air Toxics Study includes the description of the utility industry; an analysis of air toxics emissions data from fossil-fuel (coal, oil and gas) fired utilities; an assessment of risks to public health from exposure to toxics emissions through inhalation; assessment of potential risks to the public health from exposure to four specific air toxics (radionuclides, mercury, arsenic and dioxins) through other indirect means of exposure (e.g., food ingestion, dermal absorption); a general assessment of the fate and transport of mercury through environmental media; and a discussion of alternative control strategies.

The Utility Air Toxics Study's key findings indicated that mercury emissions from coal-fired electric generating units are the "hazardous air pollutant of greatest potential public health concern." The modeling assessment in the Utility Air Toxics Study also indicated evidence of a plausible link between emissions of mercury from electric generating units and the methylmercury found in soil, water, air and fish.

### 6.1.3 Utility Air Toxics Determination

On December 14, 2000, following the issuance of the Utility Air Toxics Study, U.S. EPA announced its finding that it was "appropriate and necessary" to regulate power plant emissions under section 112 of the Clean Air Act, as amended in 1990. This finding triggered a requirement for U.S. EPA to propose regulations to control air toxics emissions, including mercury from power plants, by December 15, 2003. Details of the notice of regulatory finding can be found in the *Federal Register* published December 20, 2000 (65 *Federal Register* 79825).

### 6.1.4 Clean Air Mercury Rule (CAMR)

U.S. EPA proposed the Clean Air Mercury Rule on December 15, 2003, and it was eventually promulgated and published in the *Federal Register* on May 18, 2005. The CAMR used the New Source Performance Standards (NSPS) under Section 111 of the CAA to set emissions limits for new sources and a cap-and-trade system for all existing and new coal-fired EGUs. Table 6.1 lists the final NSPS for mercury that must be met by new coal-fired EGUs.

**Table 6.1 – Emissions Standards for New Units, 40 CFR Part 60, Subpart Da**

| New Units | Emission Standards |
|---|---|
| Bituminous units | 0.0026 nanogram per joule (21 x $10^{-6}$ pounds per megawatt hour (lb/MWh)) |
| Subituminous units | |
| wet FGD | 0.0053 ng/J (42 x $10^{-6}$ lb/MWh) |
| dry FGD | 0.0098 ng/J (78 x $10^{-6}$ lb/MWh) |
| Lignite Units | 0.0183 ng/J (145 x $10^{-6}$ lb/MWh) |
| Coal Refuse Units | 0.00018 ng/J (1.4 x $10^{-6}$ lb/MWh) |
| IGCC | 0.0025 ng/J (20 x $10^{-6}$ lb/MWh) |

The NSPS limits in CAMR are more than three times less stringent than the MACT limits issued in the proposed rule, and are less stringent than the level of emissions reduction achieved by the best performing unit in each of the subcategories for which U.S. EPA issued a standard.

The CAMR cap and trade system is largely based on U.S. EPA's Acid Rain Program. The CAMR is designed as a two-phased cap and trade system. The first phase sets a nationwide cap of 38 tons in 2010, the level of mercury emissions reductions expected as co-benefit controls from the Clean Air Interstate Rule ("CAIR"). In the second phase of the CAMR trading system, mercury emissions are capped nationwide to 15 tons per year by 2018.

The cap-and-trade program allows EGUs to purchase mercury emission allowances from other EGUs and potentially bank these allowances to meet compliance requirements in future years. This would allow many power plants to avoid any reductions in their mercury emissions, and could delay full compliance with the 2018 cap until many years later.

Illinois' budget under CAMR is equivalent to 51,001 ounces of mercury for the first phase in 2010 and 20,126 ounces of mercury for the second phase in 2018. Under CAMR requirements, each state must submit a plan describing how the mercury emissions budget will be achieved by coal-fired power plants, although the States are not required to adopt a trading scheme or set unit caps to demonstrate compliance.

CAMR includes a model rule that states can adopt to achieve and maintain their own mercury emissions budgets. States may join the trading program by adopting the model trading rule in state regulations, or they may adopt regulations that mirror the necessary components of the model trading rule. For states that opt out of the trading program, mercury allocations set by CAMR become fixed emission budgets.

### 6.1.5 Other Federal Actions

On October 21, 2005, U.S. EPA issued a notice of proposed rulemaking to reconsider certain aspects of its final Clean Air Mercury Rule. This action was in response to petitions submitted by 14 states and various interests groups objecting to the CAMR proposal.

In a separate action, U.S. EPA also published a proposed action to reconsider certain aspects of its final action revising the December 2000 decision regarding regulation of electric utility steam generating units under section 112 of the Clean Air Act, as amended in 1990.

The CAMR and the related "Revision of December 2000 Regulatory Finding on the Emissions of Hazardous Air Pollutants From Electric Utility Steam Generating Units and the Removal of Coal- and Oil-Fired Electric Utility Steam Generating Units from the Section 112(c) List" are currently being challenged by a number of Petitioners in the United States Court of Appeals for the District of Columbia Circuit. *See State of New Jersey, et. al. v United States Environmental Protection Agency,* Docket No. 05-1097 and consolidated cases. In addition, the U.S. EPA granted reconsideration of certain aspects of the CAMR and the related revisions of the December 2000 Regulatory Finding as a result of receiving Petitions for Reconsideration. *See,* 70 *Federal Register* 62200 and 62213 (October 28, 2005). Both challenges have been consolidated, and the proceedings are being held in abeyance pending completion of the U.S. EPA's reconsideration proceedings, which the U.S. EPA anticipates completing by May 31,2006.

## 6.2 Other States Efforts to Reduce Mercury Emissions from Electric Generating Units (EGUs)

There is a growing list of states that have adopted regulatory programs that are more stringent than the recommended requirements in the final CAMR. The states of Connecticut, Massachusetts, Minnesota, New Hampshire, New Jersey, North Carolina and Wisconsin have all adopted legislation or regulations that far exceed CAMR requirements (Table 6.2). Other states, including Michigan, Maryland, Montana, New Hampshire, New York, North Carolina, and Virginia have announced plans, or have pending proposals addressing mercury emissions from coal-fired EGUs that exceed CAMR requirements.

**Table 6.2: Existing State Programs to Control Mercury emissions from Coal-Fired Electric Generating Units**

| State | Program |
|---|---|
| Connecticut | 90 percent control or 0.06 lbs per trillion BTU, whichever is less stringent, by 2008 (statute) |
| Massachusetts | 85 percent capture or 0.0075 lbs/GWh by 1/1/2008; 95 percent or 0.0025 lbs/GWh by 10/1/2012 (regulation) |
| Minnesota | 70 percent reduction in mercury emissions from 1990 levels by 2005 (statutory requirement - applies to all emissions, including utilities). 93 percent reduction goal proposed—the schedule and methods of achieving the goal are to be developed. |
| New Hampshire | A cap of 50 lbs per year after federal compliance dates; cap of 24 lbs per year four years later. |
| New Jersey | 90 percent reduction in emissions or 3 mg per MWh by 12/15/2007 (regulation); 5-year extension to 12/15/2012 available if multipollutant control is being installed on all units for NOx, SO2, total suspended particulates and mercury. |
| North Carolina | 64 percent reduction in mercury by 2013; recommendations for additional reduction due in 2005 (statute) |
| Wisconsin | 40 percent reduction by 2010; 75 percent reduction by 2015 (regulation). Goal of 80 percent reduction by 2018 (regulation) |

In a more recent action, Pennsylvania unveiled plans to require 80 percent mercury removal by 2010 and 90 percent by 2015. Georgia proposed to require 80-85 percent average capture efficiency by 2010, followed by 90 percent capture efficiency between 2012 and 2015 (Argus

Air Daily, 2/23/2006).

## 6.3 Illinois Mercury Reduction Programs

Because mercury is of such a significant concern to human health and the environment, Illinois EPA has adopted legislation and implemented a number of programs to reduce mercury emissions to the environment. These programs, as well as pending legislation, are described below.

### 6.3.1 Existing Programs

#### 6.3.1.1. Mercury Switches, Relays and School Use of Mercury

In 2004, P.A. 93-964/SB 2551 was enacted, prohibiting the sale of mercury electrical switches and relays (with exemptions) in consumer and commercial products, effective July 1, 2007. It also restricted the use of elemental mercury and mercury-containing scientific equipment in K-12 schools, effective July 1, 2005. The ban does not apply to the sale of mercury switches or relays used as replacement parts in existing manufacturing equipment or machinery, or where they are integrated with other components. Manufactures and users of mercury switches and relays may petition Illinois EPA for an exemption from the sales prohibition if an effective program for recycling such items is in place. Illinois EPA has developed rules to review requests for exemptions. The Pollution Control Board also adopted an Illinois EPA proposal to designate mercury switches and relays as "universal waste" to facilitate the recycling of such items at the end of their useful life.

#### 6.3.1.2. Mercury Switch Thermostats and Vehicle Components

P.A. 93-964/SB 2551 required Illinois EPA to prepare a report on options for reducing and recycling mercury found in motor vehicle components as well as wall-mounted thermostats used for heating and cooling purposes. In February 2005, Illinois EPA issued a report recommending that a statewide program be created and funded by automakers, steel manufacturers, and auto shredders to remove and safely manage mercury switches from end-of-life vehicles before they are processed as scrap metal. Illinois EPA recommended that auto recyclers and dismantlers be reimbursed for the costs of removing mercury switches from such vehicles. Illinois EPA estimated the cost of managing a mercury switch collection program in Illinois to be approximately $1 million a year for the first several years of operation. The report also recommended several improvements for the recycling of mercury switch thermostats by the Thermostat Recycling Corporation.

In January 2006, HB 5578 was introduced into the General Assembly, which would require automakers to create a statewide program to collect, transport and recycle mercury switches from discarded or end-of-life vehicles before they are processed as scrap metal. Mercury switches may be found in hood and trunk convenience lighting of vehicles manufactured before 2003 and some anti-lock brake systems on four-wheel drive vehicles. An agreement was reached among the interested parties to make the program voluntary in the first year of operation. Illinois EPA would work with the automakers to promote the program and educate auto recyclers and dismantlers on proper switch removal and handling practices. If capture rate targets are not met in the second or third year of operation, the automakers would provide auto recyclers and scrap metal processors a $2 bounty for each switch removed. Auto recyclers would also be required to remove all reasonably accessible switches before end-of-life vehicles are sent off-site for shredding and recycling. The law would sunset on July 1, 2011. The bill passed the House and is currently pending in the Senate. A companion bill, SB 2884, passed the Senate and is pending in the House.

#### 6.3.1.3 School Chemical Collections

Illinois EPA has created a program to help K-12 schools properly dispose of waste chemicals used for teaching purposes. Over the last three years, approximately 419 schools have received assistance in properly disposing of more than 1,086 fifty-five gallon drums of waste chemicals, including more than 97 drums of bulk mercury and mercury-containing devices. Most of these same schools participated in Illinois EPA's *Safe Chemicals in Education* Workshops.

#### 6.3.1.4. Household Hazardous Waste Collections

Illinois EPA's Bureau of Land program on household hazardous waste collections has been collecting mercury containing products as part of its Household Hazardous Waste Collections for a number of years.

#### 6.3.1.5. Mercury Monitoring

Illinois EPA has one of the most extensive mercury monitoring programs underway in the nation. An air sampling station in Northbrook in 2000 is one of only two continuous mercury-monitoring stations in the U.S. Mercury samples are also being collected using advanced scientific techniques at several inland lakes and streams across the state.

It is Illinois EPA's intent to change the general mercury monitoring requirements in NPDES permits. Beginning with new or reissued permits public noticed in July, any effluent mercury monitoring must use U.S. EPA Method 1631. The new laboratory method allows the evaluation of the State's water quality standard for mercury (12 ppt for most). Neighboring states have required Method 1631 for several years. This includes all major municipal permits and pretreatment communities. While not all industrial facilities monitor for mercury, industries such as power plants that may have coal residues in their wastewater effluents are required to conduct monitoring.

#### 6.3.1.6. Quicksilver Caucus Participation

Illinois EPA participates in the Quicksilver Caucus, a national mercury work group.

#### 6.3.1.7. Dental Amalgam Partnership

Illinois EPA has teamed up with the Illinois State Dental Society to arrange for mercury and mercury amalgams to be disposed of in an environmentally friendly manner at the household hazardous waste collections being held around the state this spring.

#### 6.3.1.8 Mercury Thermostat Workgroup

Illinois EPA, in conjunction with Region V, is participating on the Product Stewardship Institute's mercury thermostat workgroup. The goal of the workgroup is to increase participation in programs for recycling mercury thermostats. Illinois EPA has been promoting the National Thermostat Recycling Corporation's thermostat collection program to HVAC contractors in the state through direct mailings and other educational outreach activities.

#### 6.3.1.9 Outreach and Education

Public education and outreach efforts on the hazards of mercury are being conducted by Illinois EPA through the distribution of brochures, public service announcements, and the Agency's web site.

### 6.3.2 Mercury Reductions from Municipal Waste Combustion Source

The combustion of municipal solid wastes (MWC) was a source category identified by U.S. EPA in its Mercury Study (U.S. EPA Mercury Study, 1997) as a significant contributor of mercury emissions. U.S. EPA issued final emissions guidelines (EG) for large MWC, i.e., units with combustion design capacity over 250 tons per day capacity, on December 19, 1995 (60 *Federal Register* 65387), and for small MWCs, i.e., units with combustion design capacity of over 35 tons per day to less than or equal to 250 tons per day capacity, on December 6, 2000 (65 *Federal Register* 76378). New MWC sources are subject to the NSPS for both large and small MWC, while existing sources are covered under plans developed by states to enforce the requirements of the final Emissions Guidelines for both large and small MWCs under Clean Air Act Section 129.

Illinois' plan for large MWC was approved by U.S. EPA (62 *Federal Register* 67572) in December 1997. There were no municipal waste combustion units affected by the small MWC EG. Hence, a negative declaration for small MWC EG was filed with U.S. EPA and approved on November 30, 2001 (66 *Federal Register* 59713).

The NSPS/EG for large MWC affected two large sources in Illinois, i.e., Northwest Waste to Energy (Northwest) and Robbins Resource Recovery Company (Robbins). Northwest shutdown incinerator operations during the regulatory development process, and Robbins shutdown incinerator operations in 1998. Thus, Illinois does not have any mercury emissions from the municipal waste combustors category.

### 6.3.3. Mercury Reductions from Medical Waste Incinerator Sources

Medical Waste Incinerators were also identified as major contributors of mercury emissions in the Mercury Study. U.S. EPA proposed NSPS standards and guidelines for new and existing medical waste incinerators on February 27, 1995 (60 *Federal Register* 10654). Final standards and emission guidelines for medical waste incinerators (Subpart Ce, 40 CFR Part 60) were promulgated on September 15, 1997 (62 *Federal Register* 48348). The promulgated standards and guidelines established emissions limits for particulate matter (PM), opacity, sulfur dioxide (SO2), hydrogen chloride (HCl), oxides of nitrogen (NOx), carbon monoxide (CO), lead (Pb), cadmium (Cd), mercury (Hg), dioxins and dibenzofurans (dioxins/furans), and fugitive ash emissions.

Illinois' SIP for medical waste incinerators was approved by U.S. EPA on July 7, 1999. The State rule adopted the promulgated emission guidelines addressing all hazardous pollutants, including mercury emissions, from the combustion of hospital and medical/infectious wastes. There were 98 potentially affected sources in Illinois at the time of rule development. With the implementation of the State plan, the majority of the 98 affected sources have ceased incineration operations and have opted for other disposal options for their hospital and medical wastes. There are currently five medical waste incinerator units in operation at hospitals. As of this writing, all but three of these units have approved plans to shutdown their operations.

Thus, mercury emissions from medical waste incinerators in the State have been trending significantly lower since the development of the State plan.

## 7.0 Illinois Mercury Emissions Standards for Coal-fired Electric Generating Units

## 7.1 Rule Development Considerations

### 7.1.1 Basic Guiding Principles

Illinois recognizes that technology advancements over the last several years have contributed to both a significant reduction in costs and an increased effectiveness of controlling mercury emissions. Based in part on these developments, Illinois believes it is appropriate to require emission reductions that go beyond the federal CAMR. Expectations are that technological advancements will continue, which provides further justification for controlling mercury beyond CAMR.

In developing the proposed rule, Illinois relied on several basic principles as guidance:

- The need to protect human health, fish and wildlife, and the environment from the harmful effects of mercury and methylmercury
- The need to control the unregulated mercury emissions from Illinois' coal-fired power plants to the greatest level possible and as quickly as possible in a cost-effective manner
- Must consider the latest control technology that has been shown effective in controlling mercury emissions and which can be reasonably employed, in a cost effective manner, across the full fleet of Illinois power plants and coal types
- Must ensure that the required mercury reductions occur both in Illinois and at every power plant in Illinois to address local impacts
- The final rule needs to incorporate flexibility in complying with the proposed standards to assist in widespread compliance and to help reduce compliance costs; and
- The proposed rule must be consistent with the Governor's proposal to reduce mercury emissions in Illinois by 90 percent

### 7.1.2 Other Rule Development Considerations

The Illinois mercury rule is designed to achieve a high level of mercury control in a cost-effective manner so as to minimize the potential for any adverse impacts, such as those on Illinois' economy. Accordingly, Illinois crafted the rule using a combination of the following:

- Careful selection of an achievable, reasonable and cost-effective mercury reduction target
- Rule flexibility

#### 7.1.2.1 Selecting an Achieveable; Reasonable; and Cost-Effective Level of Mercury Control

Forecasting the costs of mercury controls is complex due to the many variables involved in such a determination, including coal type, existing controls, boiler type, fly ash needs, timing, etc. Also, with the advance of new regulations affecting nearly every pollutant emitted from power plants, many plant characteristics may change as a result of different control strategies employed to address the other pollutants (e.g., SO2 and NOx). For example, a unit that is either now controlled by, or in the future will be controlled by the combination of a scrubber, SCR, and ESP may not need to add ACI to achieve the required mercury reductions as these existing controls may do so as a co-benefit. Furthermore, as previous regulations influenced the decision to switch to lower sulfur western coals in Illinois, upcoming regulations may make a return to Illinois coals more desirable. Obviously, the costs of controls and plant configurations are changing and the many variables involved lead to the determination of "best estimates" of costs and technology employed to meet regulations.

The cost estimates presented in this document are based on the best and most current information available, but may need to be updated as the landscape evolves. The notable trend that is expected to continue is one where technological advances and vendor expansion lead to decreasing costs and increasing control efficiencies and options.

In compiling information and reaching conclusions on costs and controls, Illinois considered information from a number of sources. These included discussions with acknowledged experts in the power sector, numerous literature reviews, analyses of widely accepted technological tools such as the Integrated Planning model, review of publications by other relevant organizations (e.g. Michigan Mercury Report), review of U.S. EPA publications on control equipment costs, detailed review of the Illinois power sector, and the knowledge and experience of staff. Deference was given to more recent information since the technologies and costs involved are rapidly advancing.

Section 8.0 provides a detailed discussion of data supporting 90 percent reduction as an achievable and reasonable level of mercury control. Section 8.0 also shows that the costs of controlling mercury are consistent with Illinois' goals.

#### 7.1.2.2 Rule Flexibility

Providing flexibility in rules is always desirable provided the objectives of the rule are still achieved. Giving flexibility serves to reduce compliance costs in a variety of manners, including allowing sources to choose the most cost-effective means of compliance among different options. For example, compliance with an output-based standard may be more desirable for a source that utilizes washed bituminous coal and has existing controls consisting of a scrubber, SCR, and ESP. Such a source could likely avoid the cost of installing any additional control device since the existing controls would likely achieve compliance with the standard. Illinois can achieve the required mercury reductions proposed by Governor Blagojevich and give some flexibility to sources on compliance.

Flexibility provided by the Illinois rule includes the following:

- The rule does not mandate a certain compliance standard, rather it provides the option of choosing between two standards derived differently. One standard is a mercury reduction efficiency and the other is an output based emission rate.
- The rule does not prescribe how compliance with the selected standard is to be achieved. Instead, the source makes the ultimate decision on how compliance is obtained. For example, a source may choose to install mercury specific controls, to optimize existing controls, or to employ a multi-pollutant control strategy that achieves the required mercury control as a co-benefit.
- The rule phases in standards over a period of 3 ½ years, with a less restrictive standard in phase one. Phasing in standards, such that earlier phases are less restrictive, allows time for knowledge and experience to be gained and applied to final compliance methods and strategies – as well as to provide time for technology advancements.
- The rule allows a source to demonstrate compliance by averaging. Phase 1 allows for both system-wide and plant-wide averaging. Phase 2 allows for plant-wide averaging. Averaging allows for EGUs that can be overcontrolled to compensate for those that

cannot readily reach compliance, or for units that it is decided should not reach that level of control, because the system or plant is still able to achieve compliance.

- The rule allows for sources that commit to shutdown within a certain timetable to avoid installing controls. This allows sources to avoid unnecessary costs and expenditure of resources on units that will soon be permanently shutdown and emit no mercury.

Overall, careful consideration was given to the effect mercury control requirements will have on Illinois' economy, including consumers and the power sector. The costs associated with controlling mercury have decreased considerably as technologies have improved and options have expanded. This trend is expected to continue. Compliance flexibility should also serve to minimize costs. Regardless of all the mechanisms one can utilize to forecast a rule's impact on costs it must be recognized that there lies a degree of uncertainty that can never be eliminated. In Illinois this may be particularly true as the State moves toward deregulation with the lifting of a 10 year freeze on retail rates in January 2007.

## 7.2 Proposed Illinois Mercury Standards

### 7.2.1 Applicability

The proposed mercury standards apply to all stationary coal-fired electric generating units (EGUs), with a nameplate capacity of more 25 MWe producing electricity for sale. The proposal also applies to any cogeneration units that serve a generator with a nameplate capacity of more than 25 Mwe and supplying in any calendar year more than one-third of the unit's potential electric output capacity or 219,000 MWh.

### 7.2.2 Proposed Mercury Standards and Emissions Limits

#### 7.2.2.1 Input Mercury Reductions or Output-Based Emissions Limit

The proposed mercury standard requires that affected units comply with a 90 percent mass-based reduction of input mercury, or in the alternative, meet an output-based emissions limits of 0.0080 pounds of mercury per gigawatt-hour (GWh) of gross electrical output across their affected units.

The proposed rule is implemented in two phases. The first phase, which begins July 1, 2009, allows owners and operators of one or more affected EGUs or cogeneration units in Illinois the option to comply with either the mass-based reduction or the emission limits through a system-wide averaging demonstration as explained further below. This format provides maximum flexibility for affected sources to achieve compliance with the proposed standards. In addition, and to prevent the potential for "hot spots," each source (or plant) in the averaging demonstration must meet at least a 75 percent reduction of input mercury, or in the alternative, meet an output-based emission limit of 0.020 lbs/GWh gross electrical output.

The second phase, which begins in January 1, 2013, requires a 90 percent mass-based reduction of input mercury at each source, or in the alternative, meet an output-based source-wide emissions limit of 0.0080 lbs/GWh.

In all cases, compliance with the above standards is on a 12-month rolling basis and may be demonstrated through the 'averaging demonstration' as described in section 7.2.2.3 below.

#### 7.2.2.2 Rationale for the Proposed Mercury Standards

The output-based mercury emissions limit was developed based on four key goals:

- Give some credit for mercury removal from pre-combustion processes such as coal washing
- Provide compliance flexibility
- Obtain mercury cuts consistent with the Governor Blagojevich's proposal
- Encourage efficiency

Pre-Combustion Mercury Removal

Credit for pre-combustion mercury removal operations, such as coal washing, was desirable since the standard performance based control efficiency does not account for mercury removed during the coal washing process. However, it is clear that pre-combustion mercury removal is a viable means of reducing mercury emissions. The main focus was on coal washing since this is currently the only pre-combustion process in use in Illinois. Although companies wash coal for several reasons other than mercury control, significant levels of mercury can be removed through washing and prevented from being emitted as a result of combustion. Giving total credit for all the mercury removed during washing was contemplated, however, this would require a mercury content measurement and verification of "run of mine" coal. This process presented several significant compliance issues, including most importantly, reliance upon data from parties outside of those directly responsible for compliance. In addition, coal washing is occurring and will continue regardless of credit being given for the mercury removed. Furthermore, giving full credit for coal washing could present problems with a demonstration of general equivalence with the 90 percent reduction requirement or even the requirements of CAMR since its cap accounted for mercury removal due to coal washing.

The following is a rough calculation performed for purposes of estimating an appropriate lower-end output-based limit for giving partial credit for coal washing:

> Median Illinois coal mercury content assumed to be 10.24 lb Hg/TBtu. (Note that approximately 60% of Illinois coal is between 4 and 13 lb.) Conversion factor: 1.0 lb/TBtu = 0.011 lb/GWh
>
> When considering coal washing, average reduction due to coal washing = 47%.
>
> 10.24 lb Hg/TBtu x (1 - .47) = 5.43 lbs Hg/TBtu washed coal.
>
> Unwashed, the burning of this coal would require a control system to achieve 90% reduction. Solving for the equivalent output based standard at 90% control gives: (5.43 lb Hg/TBtu x 0.011 lb/GWh) x (1 - .90) = 0.0060 lbs Hg/GWh.
>
> Therefore, any output based standard above 0.0060 lbs Hg/GWh affords some credit for coal washing as 90% mercury removal would not be required post combustion, instead a lower level would be necessary to the extent the output based standard is higher. This limit could be considered the lower bound for any output based standard.
>
> For example, if an output based standard of 0.0080 lbs Hg/GWH were selected, one could solve for the required post combustion mercury control required, as follows: (5.43 lb Hg/TBtu x 0.011 lb/GWh) x (1 - X) = 0.0080 lbs Hg/GWh.
> Where X = the necessary mercury control to reach compliance. X = 87%.

Power plants in Illinois that burn Illinois coal typically have a scrubber and ESP control and have or are expected to have an SCR. A mercury control level of 87% is achievable with optimization of these existing controls.

Flexibility

Compliance flexibility was desired because the control efficiency standard is aggressive and flexibility assists in the achievement of widespread compliance. The availability of a second option for compliance, instead of only a single option of the control efficiency requirement, introduces considerable flexibility. When options for compliance are allowed, flexibility is provided. The proposed rule offers flexibility by allowing owners and operators the option to comply with either a mass-based or output-based standard. Further flexibility is included in the proposed rule as it provides sources the option to alternate standards as often as they wish, so long as only one standard is used per calendar month.

Encourage Boiler Efficiency

An improvement in boiler efficiency results in less coal being burned, and hence fewer emissions from a boiler, to generate the same amount of electrical output. An output-based limit accommodates and inherently encourages changes to improve boiler efficiency.

Mercury Reductions

The emission reductions obtained from an optional output based standard need to be roughly equivalent to the reductions required by the control efficiency standard. In the original gross estimate of the reductions resulting from a 90% control efficiency requirement, the 2002 uncontrolled mercury emissions in Illinois were estimated to be 7,022 pounds. Therefore, a 90% reduction from this starting point results in final mercury emissions, after the Governor Blagojevich's proposal, of 702 pounds per year. In computing an output based emission limit that would be roughly equivalent to 90% reduction, a logical starting point would be the 702 pounds of mercury emissions, i.e., the expected final outcome of the proposal. Back calculating from this number using Illinois' total electrical output gives an emission rate that can be considered to provide the same level of reductions as the 90% control requirement.

Illinois electric gross output reported for 2002 per EIA for Illinois coal-fired EGU's equals 84 TWh.

702 lbs Hg/(84 TWh x 1000 GWh/TWh) = 0.0084 lbs Hg/GWh.

Therefore, any emission rate lower than this rate could be considered to result in less than 702 pounds of mercury per year. This can be considered an upper bound value to any proposed output based standard.

Based on the above discussions, an output based limit of 0.0080 lbs Hg/GWh was chosen. This limit is within the range of 0.0060 – 0.0084 lbs Hg/GWh.

Note that 702 pounds is significantly lower (44%) than the final federal mercury budget under CAMR of 1,258 pounds per year starting at 2018.

For purposes of determining an output based standard to correlate with the 75% plant-wide reduction levels in phase 1, a pro rata calculation was used:
0.0080/(1-.90) = X/(1-.75) = 0.020 lbs Hg/GWh.

**7.2.2.3 Averaging Demonstration**

Owners and operators of affected sources may demonstrate compliance with the proposed standards through an "averaging demonstration" (Demonstration). Averaging demonstration means compliance that is based on the combined performance of one or more EGUs at different plants (system-wide averaging) or two or more EGUs at a single plant (source-wide averaging). Compliance by source-wide demonstration means that the source shall meet or exceed, on a 12-month rolling basis, the 90 percent or the minimum 75 percent mass-based reduction of input mercury. As an alternative to the mass-based reduction requirement, the source shall not exceed, on a 12-month rolling basis, the output-based limit of 0.0080 lbs/GWh or the minimum of 0.020 lbs/GWh.

System-wide demonstration means averaging between two or more plants and requires that the owner or operator identify the affected units and sources (or plants) that will be included in the demonstration. Compliance through system-wide demonstration means that the actual average mass-based reduction shall be at or above 90 percent system-wide, and at least 75 percent source-wide reduction.

### 7.2.3 Monitoring Requirements

The proposed Illinois mercury rule would require sources to conduct emissions monitoring for mercury that is identical to the emissions monitoring that would be required under CAMR. These monitoring practices have been promulgated by U.S. EPA at 40 CFR Part 75, Subpart I, Hg Mass Emission Provisions, and 40 CFR Part 75, Appendix K, Quality Assurance and Operating Procedures for Sorbent Trap Monitoring Systems. As provided under CAMR, a source may use the excepted "low mass" emissions monitoring methodology at 40 CFR 75.81(b) for an EGU that is eligible for this methodology, with annual emissions of no more than 29.0 pounds of mercury. The assessment of the costs of such monitoring was addressed by USEPA and can be found at 70 Fed. Reg. 28639, Section V and 28640, Section, (May 18, 2005).

In addition to monitoring mercury emissions to the atmosphere, the proposed rule would require a source complying with the 90 percent reduction standard to conduct sampling and analysis for the mercury content of the coal being burned in the EGU. This is necessary to determine the input mercury to the EGU so that the mercury removal efficiency can be calculated. Most sources already collect and analyze coal samples on a routine basis for operational reasons. The provisions for sampling in the proposed rule were developed to ensure an accurate determination of the input mercury to the EGU. Since the mercury content of coal varies, even when coming from a single mine and coal seam, and the amount of coal consumed by an EGU can vary from day to day, daily sampling of the coal supply to the EGU is required. The coal supply must be sampled at a point after long-term storage, where the sample will be representative of the coal being burned in the EGU on the day that the sample is taken. This location for coal sampling was selected after consultation with industry representatives to provide flexibility in the point at which samples are collected while ensuring that the resulting data accurately reflects the coal that is actually being burned in the EGU. Certain ASTM Methods were selected for the required analyses, i.e., ASTM D6414-01 (Standard Test Method for Total Mercury in Coal and Coal Combustion Residues by Acid Extraction or Wet Oxidation/Cold Vapor Atomic Absorption) and ASTM D3684-01 (Standard Test Method for Total Mercury in Coal by the Oxygen Bomb Combustion/Atomic Absorption Method). These methods were chosen after consultation with industry representatives and experts on coal analysis because these methods are accurate, sources and commercial laboratories are familiar with these methods, and the costs of these methods are reasonable.

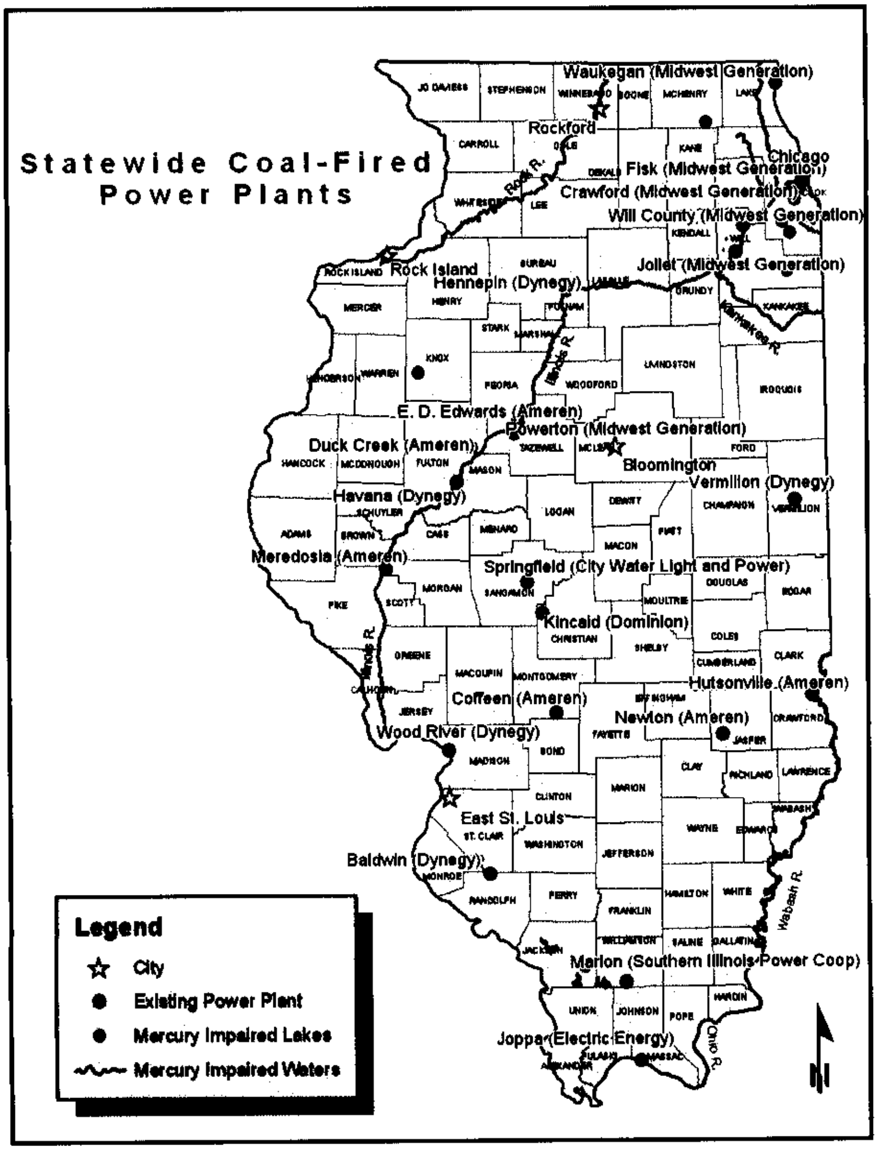
#### 7.2.3.1 Illinois Electric Generating Units

Below is the list of Illinois EGUs. There are currently 59 electric generating units (Table 7.1) operating at 21 power plants across the State, as shown in Figure 7.1.

**Table 7.1 - Existing Illinois Electric Generating Units**

| OWNER | FacilityId | FACILITY_NAME | ORIS | UNIT |
|---|---|---|---|---|
| Dynegy Power Corporation (Owner/Operator) | 157851AAA | Baldwin Energy Complex | 889 | 1 |
| Dynegy Power Corporation (Owner/Operator) | 157851AAA | Baldwin Energy Complex | 889 | 2 |
| Dynegy Power Corporation (Owner/Operator) | 157851AAA | Baldwin Energy Complex | 889 | 3 |
| Ameren Energy Generating Company (Owner/Operator) | 135803AAA | Coffeen | 861 | 1 |
| Ameren Energy Generating Company (Owner/Operator) | 135803AAA | Coffeen | 861 | 2 |
| Midwest Generation EME, LLC (Owner/Operator) | 031600AIN | Crawford | 867 | 7 |
| Midwest Generation EME, LLC (Owner/Operator) | 031600AIN | Crawford | 867 | 8 |
| City of Springfield, IL (Owner/Operator) | 167120AAO | Dallman | 963 | 31 |
| City of Springfield, IL (Owner/Operator) | 167120AAO | Dallman | 963 | 32 |
| City of Springfield, IL (Owner/Operator) | 167120AAO | Dallman | 963 | 33 |
| AmerenEnergy Resources Generating Company (Owner/Operator) | 057801AAA | Duck Creek | 6016 | 1 |
| AmerenEnergy Resources Generating Company (Owner/Operator) | 143805AAG | E D Edwards | 856 | 1 |
| AmerenEnergy Resources Generating Company (Owner/Operator) | 143805AAG | E D Edwards | 856 | 2 |
| AmerenEnergy Resources Generating Company (Owner/Operator) | 143805AAG | E D Edwards | 856 | 3 |
| Midwest Generation LLC (Owner/Operator) | 031600AMI | Fisk | 886 | 19 |
| Dynegy Power Corporation (Owner/Operator) | 125804AAB | Havana | 891 | 9 |
| Dynegy Power Corporation (Owner/Operator) | 155010AAA | Hennepin Power Station | 892 | 1 |
| Dynegy Power Corporation (Owner/Operator) | 155010AAA | Hennepin Power Station | 892 | 2 |
| Ameren Energy Generating Company (Owner/Operator) | 033801AAA | Hutsonville | 863 | 5 |
| Ameren Energy Generating Company (Owner/Operator) | 033801AAA | Hutsonville | 863 | 6 |
| Midwest Generation EME, LLC (Owner/Operator) | 197809AAO | Joliet 29 | 384 | 71 |
| Midwest Generation EME, LLC (Owner/Operator) | 197809AAO | Joliet 29 | 384 | 72 |
| Midwest Generation EME, LLC (Owner/Operator) | 197809AAO | Joliet 29 | 384 | 81 |
| Midwest Generation EME, LLC (Owner/Operator) | 197809AAO | Joliet 29 | 384 | 82 |
| Midwest Generation EME, LLC (Owner/Operator) | 197809AAO | Joliet 9 | 874 | 5 |
| Electric Energy, Inc. (Owner/Operator) | 127855AAC | Joppa Steam | 887 | 1 |
| Electric Energy, Inc. (Owner/Operator) | 127855AAC | Joppa Steam | 887 | 2 |
| Electric Energy, Inc. (Owner/Operator) | 127855AAC | Joppa Steam | 887 | 3 |
| Electric Energy, Inc. (Owner/Operator) | 127855AAC | Joppa Steam | 887 | 4 |
| Electric Energy, Inc. (Owner/Operator) | 127855AAC | Joppa Steam | 887 | 5 |
| Electric Energy, Inc. (Owner/Operator) | 127855AAC | Joppa Steam | 887 | 6 |
| Dominion Energy Services Co (Operator) Kincaid Generation, LLC (Owner) | 021814AAB | Kincaid Station | 876 | 1 |
| Dominion Energy Services Co (Operator) Kincaid Generation, LLC (Owner) | 021814AAB | Kincaid Station | 876 | 2 |
| City of Springfield, IL (Owner/Operator) | 167120AAO | Lakeside | 964 | 7 |
| City of Springfield, IL (Owner/Operator) | 167120AAO | Lakeside | 964 | 8 |
| Southern Illinois Power Cooperative (Owner/Operator) | 199856AAC | Marion | 976 | 123 |
| Southern Illinois Power Cooperative (Owner/Operator) | 199856AAC | Marion | 976 | 4 |
| Ameren Energy Generating Company (Owner/Operator) | 137805AAA | Meredosia | 864 | 1 |
| Ameren Energy Generating Company (Owner/Operator) | 137805AAA | Meredosia | 864 | 2 |
| Ameren Energy Generating Company (Owner/Operator) | 137805AAA | Meredosia | 864 | 3 |
| Ameren Energy Generating Company (Owner/Operator) | 137805AAA | Meredosia | 864 | 4 |
| Ameren Energy Generating Company (Owner/Operator) | 137805AAA | Meredosia | 864 | 5 |
| Ameren Energy Generating Company (Owner/Operator) | 079808AAA | Newton | 6017 | 1 |
| Ameren Energy Generating Company (Owner/Operator) | 079808AAA | Newton | 6017 | 2 |
| Midwest Generation EME, LLC (Owner/Operator) | 179801AAA | Powerton | 879 | 51 |
| Midwest Generation EME, LLC (Owner/Operator) | 179801AAA | Powerton | 879 | 52 |
| Midwest Generation EME, LLC (Owner/Operator) | 179801AAA | Powerton | 879 | 61 |
| Midwest Generation EME, LLC (Owner/Operator) | 179801AAA | Powerton | 879 | 62 |
| Dynegy Midwest Generation, Inc. (Owner/Operator) | 183814AAA | Vermilion Power Station | 897 | 1 |
| Dynegy Midwest Generation, Inc. (Owner/Operator) | 183814AAA | Vermilion Power Station | 897 | 2 |
| Midwest Generation EME, LLC (Owner/Operator) | 097190AAC | Waukegan | 883 | 17 |
| Midwest Generation EME, LLC (Owner/Operator) | 097190AAC | Waukegan | 883 | 7 |
| Midwest Generation EME, LLC (Owner/Operator) | 097190AAC | Waukegan | 883 | 8 |
| Midwest Generation EME, LLC (Owner/Operator) | 197810AAK | Will County | 884 | 1 |
| Midwest Generation EME, LLC (Owner/Operator) | 197810AAK | Will County | 884 | 2 |

**Figure 7.1 - Locations of Illinois Coal-Fired Power Plants**



## 8.0 Technological Feasibility of Controlling Mercury Emissions from Coal-Fired Power Plants in Illinois

The mercury emissions from a coal-fired power plant are the result of the mercury content in the coal that is burned and the extent that processes in the boiler prevent the mercury from being released with the exhaust gases of the power plant. Mercury can be removed from the coal prior to combustion of the coal. This may be achieved by coal cleaning or by some other treatment of the coal. Or, mercury can be removed from the boiler flue gases by air pollution control (APC) equipment. Sometimes the APC equipment that removes the mercury is equipment that is installed primarily to remove other pollutants, such as particle matter (PM) or acid gases in a flue gas desulfurization system (FGD). These are called co-benefit mercury removal. Mercury may also be removed by air pollution control systems that are specifically designed to remove mercury from the flue gases.

Mercury emissions control technology is a rapidly advancing field. New developments continually improve capabilities to reduce mercury emissions from coal-fired power plants. The following sections address a current understanding of how mercury emissions from Illinois coal-fired power plants may be controlled.

### 8.1 Mercury Removal from Coal

Run of mine (ROM) bituminous coal is frequently cleaned for the following purposes:

- Removal of impurities to improve the heating value of the coal
- Reduction of transportation costs for coal to the power plant and ash from the power plant
- Maintenance of ash content in coal supply within contract requirements
- Removal of sulfur, mainly as pyrites, lowering $SO_2$ emissions when the coal is burned.

However, cleaning ROM coal will provide the added benefit of removing mercury from the coal. This is because mercury in the coal is preferentially associated with pyrites and other noncombustible materials that are removed in coal washing. In conventional cleaning methods the coal is crushed and separated into course, medium and fine fractions. Each of these size fractions is cleaned by different methods that may include jigs or heavy media baths (coarse), cyclones and concentrating tables (intermediate), or disposal or froth floatation (fines). Conventional cleaning methods can remove on average 47% of the coal mercury in ROM Illinois bituminous coal, as shown in Figure 8.1. Research shows that advanced cleaning techniques, such as advanced floatation or gravity separation can remove higher amounts of mercury from Illinois bituminous coal, as high as 84%. However, more advanced cleaning methods increase the amount of waste material, the amount of energy expended and the amount of coal that must be mined to produce a given amount of product coal. Therefore, there are economic and environmental trade-offs beyond mercury removal that must be considered.

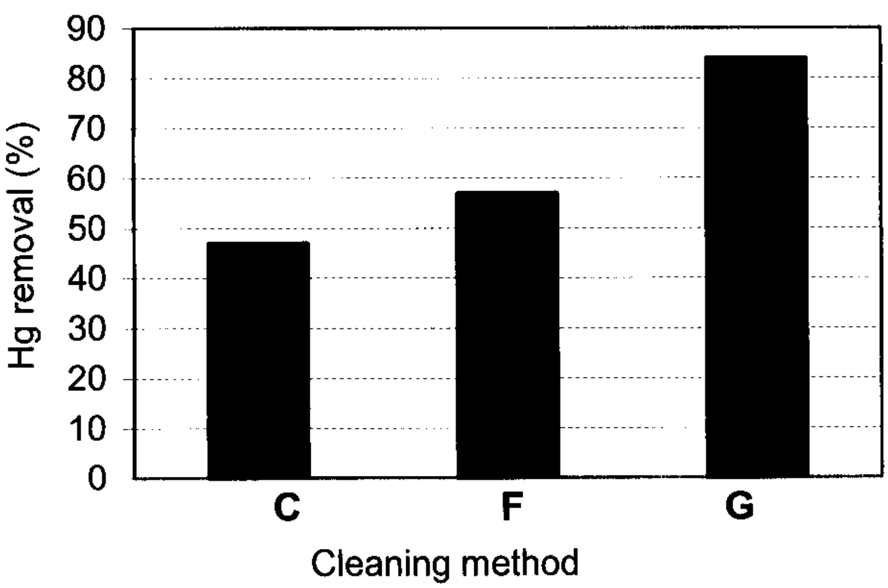



**Figure 8.1**. Mercury removal efficiency of coal cleaning methods on Illinois coal cleaned by:

- conventional cleaning (C);
- advanced flotation (F); and
- advanced gravity separation (G) (Rostam-Abadi, 2005)

### 8.1.1. Wastewater Issues in Coal Washing

Coal washing is a process capable of removing mercury from mined coal by separation of pyrites and other trace minerals. It has been estimated by the Illinois Clean Coal Institute (ICCI) that approximately 60% of mercury found in Illinois coal can be removed by routine coal washing. Even more mercury may be removed using enhanced gravity separation methods such as cyclones and flotation. Currently, most coal mines in the state of Illinois utilize some form of coal washing for various reasons including reduction in sulfur content, and enhancing burn characteristics with less ash. The washing activities are carried out at the mine preparation plants prior to shipment to customers, including coal-fired power plants. In wet washing processes the fines end up in a slurry that must be disposed of by some means. Typically, the slurry is stored in an impoundment or pumped underground.

Currently, discharges from coal washing facilities are permitted along with their associated coal mines under the NPDES permitting program. In cases where an impoundment is utilized to store the slurry, ground water monitoring is required as a condition of the facility's NPDES permit. The Class I groundwater standard for mercury (total) is 0.002 mg/l. Mercury groundwater monitoring has not been required on a routine basis, but existing mercury sampling data indicates that mercury has generally not exceeded groundwater standards due to slurry ponds. It must be noted, however, that the analytical methods used to measure mercury in groundwater are not capable of detecting mercury down to levels of interest when surface water standards are considered. The pH of the water in the slurry ponds is typically in the range of 7 to 8. Therefore, it would not appear that the mercury sulfide bound up with the pyrites would leach. However, it is conceivable that mercury monitoring (using test methods adequate for assessment) for these impoundments will become more commonplace if coal washing activities are increased.

The larger size fraction of material separated from the coal ends up in gob piles. Runoff from the gob piles is managed by routing it to sedimentation basins. Discharges from the basins are also governed by the facility's NPDES permit. Mercury is not typically a regulated parameter in the NPDES permits for sedimentation basin discharges at coal mines. The surface water quality aquatic life standards for mercury are 1.1 ug/l (chronic) and 2.2 ug/l (acute) in the dissolved form, but these standards are not constraining on a day to day basis. It is not anticipated that mercury water quality will be an issue for these discharges based on factors such as the form of mercury, settling in the basins, and the pH of wastewater. Again, it is conceivable, and probably likely, that increased monitoring for mercury will be included in new and reissued NPDES permits for various discharges in an attempt to better quantify the extent of mercury present.

## 8.2 The Fate of Mercury During Coal Combustion

Mercury that is present in trace amounts in the coal is released from the coal during combustion. At furnace conditions, the released mercury is present in a gaseous state in the elemental form that is denoted as $Hg^o$. As the combustion exhaust gases cool in the boiler, chemistry shifts to favor an oxidized, or ionic, form of mercury, denoted as $Hg^{2+}$. The temperature window where this transformation occurs varies based upon flue gas conditions, and may vary from about 620 °F to 1250 °F (EPA-600/R-01-109, 2002). The most common form of $Hg^{2+}$ is as mercuric chloride, $HgCl_2$. As the flue gas cools, some of the mercury may also form particulate or be adsorbed onto solid particles in the combustion gases. This particulate form of mercury is denoted $Hg_p$. At conditions after the last heat exchanger, normally around 300 °F, one would expect all of the mercury to be in the form of $Hg_p$ or $Hg^{2+}$ if the chemical reactions went to completion. However, in practice, the form of the mercury is normally such that some significant portion (from a few percent to over 90%) of the mercury actually remains in the elemental form ($Hg^o$). Therefore, the transformation of elemental mercury to oxidized mercury is kinetically limited – that is to say that the chemical reactions associated with mercury oxidation slow down and stop before they can reach completion.

The speciation of mercury – as $Hg^o$, $Hg^{2+}$, or $Hg_p$ – is important because it impacts the capture of mercury by boiler air pollution control equipment. $Hg^o$ is not removed by pollution control equipment without first converting it to another form of mercury – either $Hg^{2+}$ or $Hg_p$. $Hg_p$ is effectively removed by particulate matter control devices such as electrostatic precipitators (ESPs) and fabric filters (FFs) and $Hg^{2+}$ is water soluble and is efficiently removed by flue gas desulfurization equipment. The oxidation of $Hg^o$ to $Hg^{2+}$ may occur in gas-phase reactions or in heterogeneous, or catalytically-assisted, reactions. The gas-phase oxidation is believed to be influenced by several parameters – temperature and concentration of certain other constituents in the fluegas such as chlorine. The heterogeneous reactions occur mostly on fly ash surfaces or boiler surfaces. If the fly ash contains high amounts of unburned carbon the catalytic effect is greater. In addition, carbon in the fly ash acts as a sorbent. Chlorination of carbon by HCl is a likely first step toward catalytic oxidation of $Hg^o$ to $HgCl_2$ on the surface of fly ash, and chemisorption of the mercury onto the fly ash carbon can occur this way. Through this mechanism $Hg^o$ can be transformed into $Hg_p$, which can be captured by downstream PM control devices. Hence, fly ash characteristics – especially carbon - as well as coal chlorine content play an important role in mercury speciation and capture. Other constituents in the flue gas – $SO_2$ and $H_2O$ – have also been shown to affect mercury speciation, tending to suppress $Hg^o$ oxidation to $Hg^{2+}$ somewhat as concentration of $SO_2$ or $H_2O$ is increased. But, the effects of $SO_2$ and $H_2O$ are not as significant as the effects of temperature, carbon and chlorine (EPA-600/R-01-109, 2002).

Two types of coals are burned at power plants in the state of Illinois – bituminous and subbituminous. Bituminous coals burned in Illinois are usually native Illinois basin coals. Subbituminous coals are usually imported from the western states and are attractive for their low sulfur content. Bituminous coals tend to have higher chlorine contents and also tend to produce higher levels of unburned carbon (UBC) in the fly ash than subbituminous coals. Because of the importance of chlorine and carbon in oxidation of $Hg^o$, bituminous coals are more likely to produce low proportion of mercury as $Hg^o$ while subbituminous and lignite coals produce more mercury as $Hg^o$. Since the $Hg^o$ is not easily captured by existing pollution controls, the plants that burn subbituminous coals would be expected to have higher mercury emissions for the same air pollution control configuration.

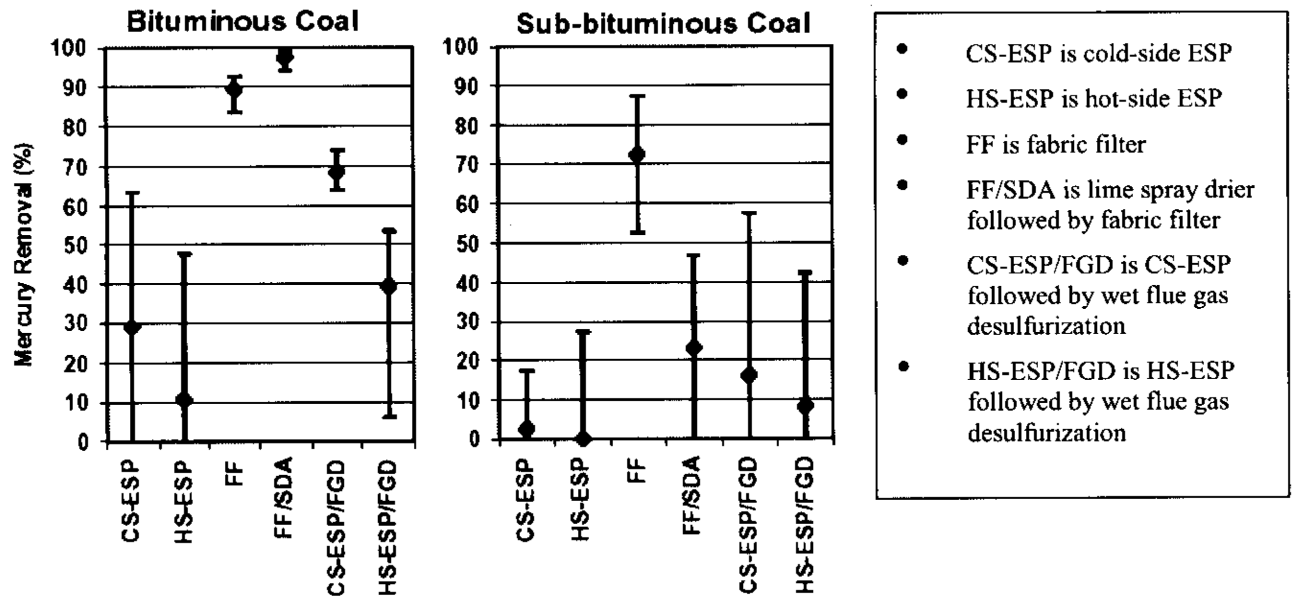
### 8.3 Mercury Removal by Co-Benefit from PM, NOx and $SO_2$ Controls

Mercury may be captured by co-benefit of particulate matter (PM) controls or $SO_2$ controls. NOx controls can enhance the capture that is achieved in PM and $SO_2$ controls. Results of measurements of co-benefit mercury removal rates taken in response to the U.S. EPA's Information Collection Request (ICR) as part of the development of the federal Clean Air Mercury Rule are shown in Figure 8.2 for bituminous and subbituminous coals with various air pollution control configurations. Figure 8.2 shows the average removal rates as well as the range that was measured for each APC configuration. There are some important trends in this figure.

- In every case, the average mercury removal rate for bituminous coal was greater than the average removal rate of subbituminous coal for the same APC configuration.

- Mercury removal for a FF was significantly higher than for a cold-side ESP (CS-ESP) than for a hot-side ESP (HS-ESP) for both bituminous and subbituminous coals.
- Removal for a bituminous coal fired boiler with Spray Dryer Absorber and FF (SDA/FF) was very high (over 95%), while for subbituminous coals removal with SDA/FF was actually less than for a FF alone.
- In several cases there was a high level of variability in capture efficiency.

**Figure 8.2 Mercury Removal Rates Measured for Bituminous and Subbituminous Coals (USEPA, 2005)**




The tendency for mercury to be captured more efficiently from boilers firing bituminous coal is likely a result of the higher chlorine contents that these coals tend to have and the higher unburned carbon in the fly ash of these coals. Both factors will contribute to lower proportions of mercury as $Hg^{o}$ and greater proportions of mercury as $Hg^{2+}$ or $Hg_p$, both of which are easier to capture than $Hg^{o}$. The carbon in fly ash also acts as a sorbent material to capture the mercury.

The improved mercury capture by FF over ESPs can be explained by the intimate contact the gas has with fly ash (and unburned carbon, or UBC) as it passes through the fabric filter. This will contribute to greater catalytic oxidation and subsequent adsorption of the mercury. Bituminous coals, generally having higher UBC contents in the fly ash, would be expected to produce higher removal rates in combination with a FF than subbituminous coals with an FF, and this is the case.

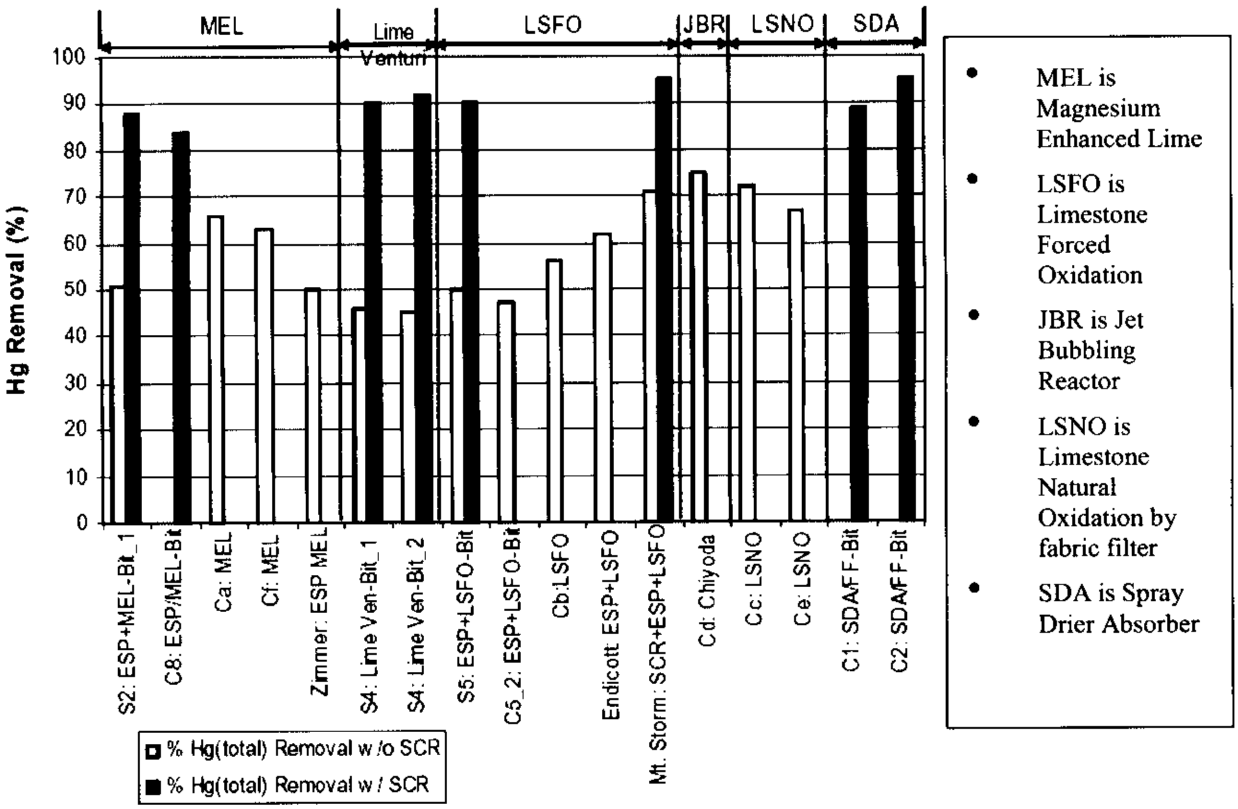
The poor removal of mercury by SDA/FF on subbituminous coals can be explained by the capture of much of the HCl by the SDA, leaving inadequate HCl at the FF to participate in the oxidation of $Hg^0$ and adsorption onto particulate that can be captured on the FF. While not used in Illinois power plants, lignite coals exhibit behavior that is similar to subbituminous coals due to their low halogen content. For bituminous coals, which usually have a higher percentage of Hg as $Hg^{2+}$, this HCl stripping effect is not significant and SDA/FFs have very high mercury removal efficiencies.

The high variability of mercury capture for several situations indicates that for these cases there are other important factors besides coal type and APC configuration. For example, the bituminous coal with CS-ESP data covers a range of coal chlorine, fly ash carbon (and content), ESP inlet temperature and coal sulfur levels – all of which can impact mercury capture efficiency. So, even within any classification of coal or control technology, there may be a significant amount of variability.

Since the ICR data was originally collected by U.S. EPA, several test programs have examined other configurations not covered in the ICR data. One configuration is Selective Catalytic Reduction equipment for NOx removal followed by flue gas desulfurization. Mercury is very effectively captured from the flue gas of boilers that fire bituminous coals and are equipped with both SCR and FGD. The catalyst of the SCR system helps to oxidize the elemental mercury in the flue gas. The oxidized mercury is then very efficiently captured by the FGD system. As shown in the Figure 8.3, effective capture in the range of about 90% appears to occur for all types of FGD when SCR is used in combination with FGD. Without the SCR, mercury removal by the FGD is in the range of about 50% to 70% (roughly consistent with the ICR data).

For subbituminous coals, the beneficial effect of SCR on mercury capture by FGD does not appear to be as great. This is believed to be due to the lower halogen concentrations in the flue gas of subbituminous coals than bituminous coals, which tends to favor elemental over oxidized mercury.

**Figure 8.3. Mercury Removal by Wet FGD Technology With and Without SCR (USEPA, 2005)**



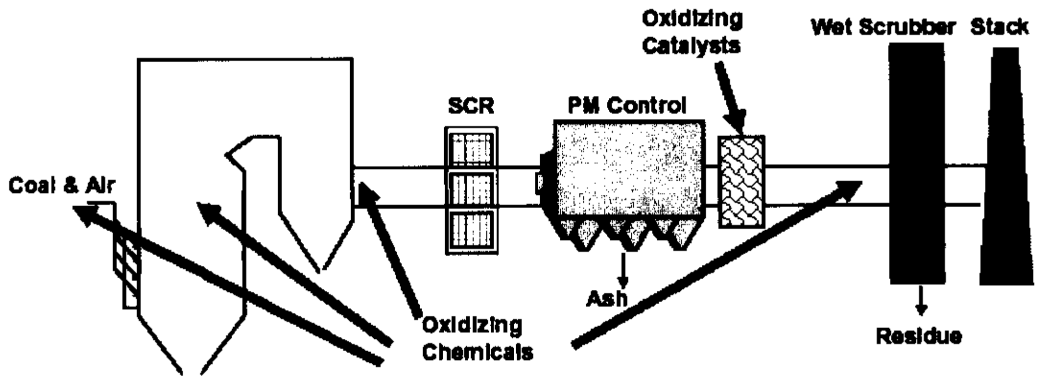

### 8.3.1 Methods to Optimize Co-benefit Controls

Methods to improve the mercury capture efficiency of PM and $SO_2$ controls are being developed and have proven to be effective in many cases. Most approaches focus on methods to increase the proportion of mercury as $Hg^{2+}$ or $Hg_p$, which tends to be much more easily captured. Others are focused on modifying some other aspect of flue gas chemistry. A description of the common methods follow:

- *Combustion Staging* – Combustion Staging is known as a method for NOx control. However, it has also been shown to help improve capture of mercury in the ESP. This is at least in part due to increased carbon in the fly ash that often results from combustion staging. The increased carbon loading tends to promote formation of $Hg^{2+}$ and also acts as a sorbent to capture the mercury. Another effect is suppression of oxidation of $SO_2$ to $SO_3$ (sulfur trioxide). $SO_3$ has been shown to suppress the mercury removal of sorbents. This is possibly because it may compete with mercury for oxidation and adsorption sites. In most cases it is not necessary to make hardware changes to affect the fuel staging. This is often achievable by making adjustments to existing hardware to reduce excess air. The extent that combustion staging will improve co-benefit mercury emissions will vary from one unit to another and for any unit would be determined in a test program.

- *Coal Blending* –For subbituminous coals, which tend to have low halogen content and also tend to produce low carbon content in the fly ash, improved mercury capture by existing equipment can result through blending with bituminous coal. For example, at Holcomb Station in Kansas, a 360 MW, PRB-fired boiler equipped with SDA/FF for $SO_2$ and PM control, mercury capture across the fabric filter was increased from zero to nearly 80% by blending about 15% western bituminous coal with the PRB coal (Sjostrom, 2004). Of course, in any particular situation, coal blending may not be the best choice because there could be impacts on the combustion system. Coal blending can also improve performance of mercury-specific technologies as well, such as sorbent injection.
- *Fuel and Flue Gas Additives* – Both subbituminous and lignite coals behave similarly with respect to mercury capture due to low halogen contents in these coals. Fuel and flue gas additives have been developed for the purpose of increasing the halogen content of the flue gas or to otherwise promote formation of $Hg^{2+}$ over $Hg^{o}$. From a mercury control perspective, these additives can make facilities firing subbituminous or lignite coals behave more like a facility that fires bituminous coals. At Laskin 2 (firing PRB) and at Stanton 10 (firing ND lignite), chlorine salts were added to the fuel to assess the impact of increasing fuel chlorine in this way has on mercury oxidation and capture. Laskin 2 is equipped with a Particle Scrubber (PS) and Stanton 10 with a SDA/FF. In both cases, mercury oxidation increased, although for some salts the mercury capture did not increase (Richardson et al., 2003). Additives might also be injected directly into the flue gas or into the air pollution control equipment, as shown in Figure 8.4. Long-term effects, such as corrosion, plugging, impacts on combustion equipment could not be assessed during the short-term parametric tests. Therefore, the use of coal additives offers some promise at improving mercury capture; however, they may have other impacts that need to be evaluated.

**Figure 8.4 Locations for Addition of Oxidizing Chemicals or Oxidizing Catalysts**



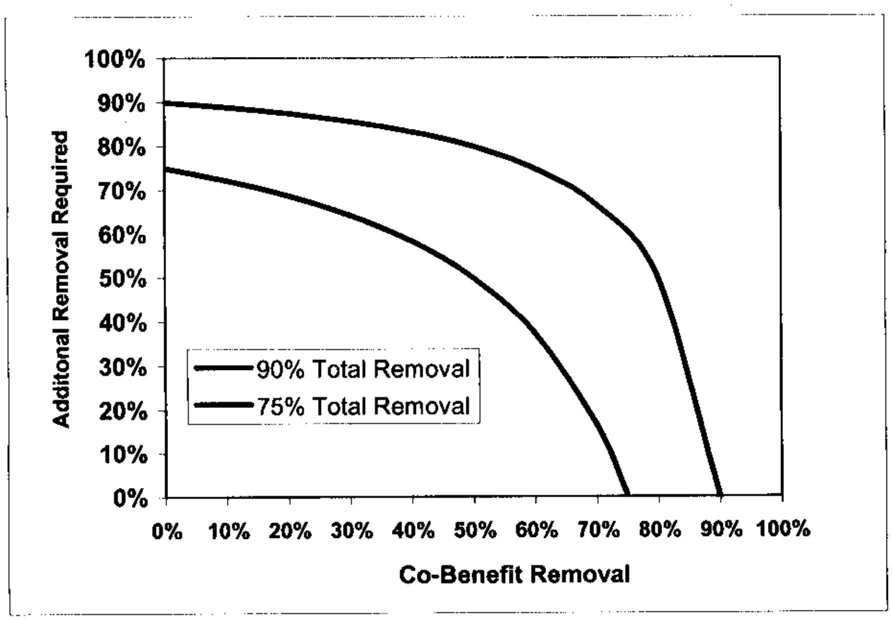

- *Flue Gas Catalysts* – In the same manner that SCR catalyst improves mercury oxidation, other catalysts might be added upstream of the wet FGD to promote oxidation of $Hg^0$ to $Hg^{2+}$ which is easily captured in the FGD. Although there has been some testing of catalysts for this purpose, catalyst lifetime remains a concern.
- *Wet FGD Additives* – Wet FGD systems are usually very effective at removing $Hg^{2+}$. However, under some operating conditions of a wet FGD a very small portion of the $Hg^{2+}$ will be chemically reduced to $Hg^0$ and the $Hg^0$ will then be reemitted (Nolan et al., 2003). This will reduce the overall Hg removal effectiveness of the FGD somewhat. In some of these cases, especially for limestone forced oxidation scrubbing systems, the chemical reductions of Hg2+ to Hgo and subsequent reemission have been abated with the help of sulfide-donating liquid reagent. Experience has shown that $Hg^{2+}$ reduction and reemission may be more difficult to avoid in magnesium-enhanced lime scrubbers than LSFO scrubbers due to the much higher sulfite concentration in these systems (Renninger et al., 2004). Development continues in this area to improve the effectiveness of these chemicals at improving mercury control efficiency of wet FGD systems.

## 8.4 Mercury-Specific Controls

The previous Section addressed the important factors impacting mercury capture by co-benefit from NOx, PM or $SO_2$ control technologies. As discussed, boilers that fire subbituminous coal –

which there currently are many of in Illinois – are not likely to achieve high levels of mercury removal from co-benefits alone. Some of the bituminous coal fired boilers may not achieve adequately low mercury emissions by co-benefits alone. Therefore, these plants may need additional controls to achieve the levels of mercury removal that are being required in the proposed rule. The level of additional removal needed by mercury-specific controls is shown in Figure 8.5 for 90% total removal and 75% total removal. As shown in Figure 8.5, the additional removal required of mercury specific technology can be substantially reduced by high levels of co-benefit removal.

**Figure 8.5. Additional Mercury Removal Required of Mercury-Specific Control Technology to Achieve 90% and 75% Total Removal as a Function of the Co-Benefit Mercury Removal.**




In this section, removal of mercury by injection of Powdered Activated Carbon and other dry, injected sorbents will be described. Mercury removal by Sorbent Injection is a control technology that has been used in other industries for mercury control and has been tested at numerous coal-fired units in the United States. After co-benefit from other controls, SI technology is the mercury control technology that is most likely to be deployed at coal-fired power plants.

SI technology is a well-established method to control mercury from Municipal Waste Combustors (MWCs) in the United States and Europe. The most widely used sorbent is PAC. However, other sorbents or reactive chemicals have been used. Whether on a MWC or on a coal-fired power plant, the equipment for a sorbent injection system consists of a storage silo, metering valve, pneumatic conveying system and a series of pipes that direct the sorbent that is blown into the plant ductwork. The sorbent is always injected upstream of a particulate matter collection device – typically either an electrostatic precipitator or fabric filter as in Figure 8.6. The dry particles are dispersed in the flue gas stream and are captured by the downstream PM collection device. When an ESP collects the sorbent, the mercury capture must occur as the sorbent and mercury interact "in-flight". For a fabric filter, there is "in-flight" interaction, but most interaction between the sorbent and mercury occurs as the gas passes through a layer of PAC collected on the surface of the filter bag.

For coal-fired applications, where it may be desirable to keep the sorbent separate from the captured fly ash (such as when the fly ash is sold for use in cement), the sorbent may be injected between fields of the ESP. This is called a TOXECON II arrangement. The bulk of the fly ash is collected in the ESP upstream of the sorbent injection point and is separated from the sorbent and remaining fly ash that is collected in the ESP downstream of the injection point as shown in the TOXECON II arrangement of Figure 8.6. In other cases it may be preferable to install a new fabric filter downstream of the existing ESP. In this case the configuration is a TOXECON arrangement as shown in Figure 8.7. This configuration has the benefits of providing segregation of fly ash from sorbent and higher mercury removal efficiencies at lower sorbent injection rates. However, the disadvantage is that the equipment is more expensive than in the case of Figure 8.6.

**Figure 8.6. Arrangement for a Typical Sorbent Injection System, Normal Arrangement in Solid and TOXECON II in Dashed**

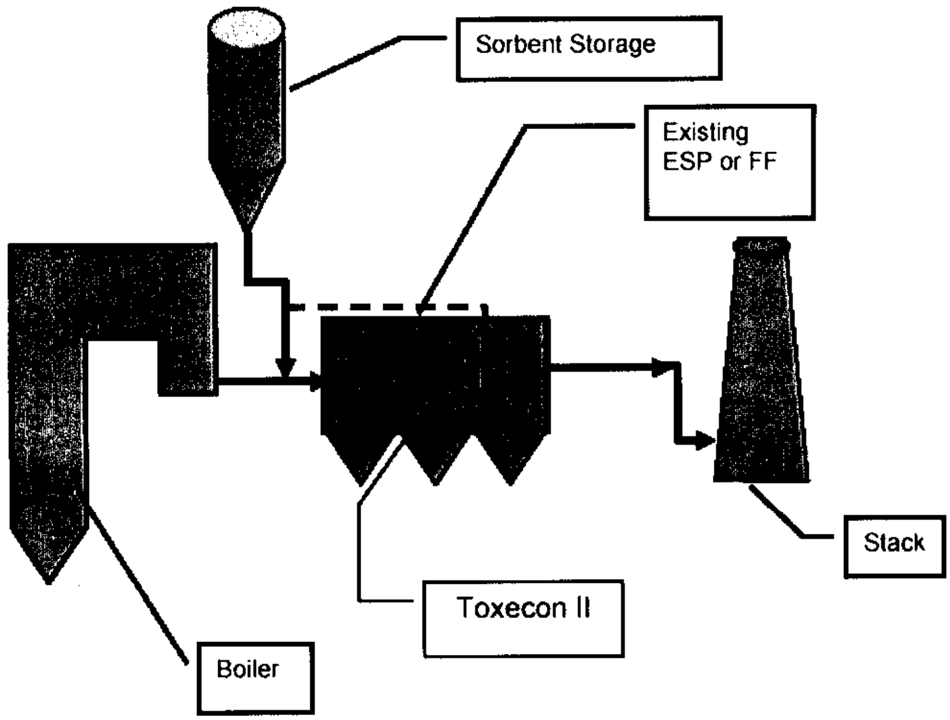
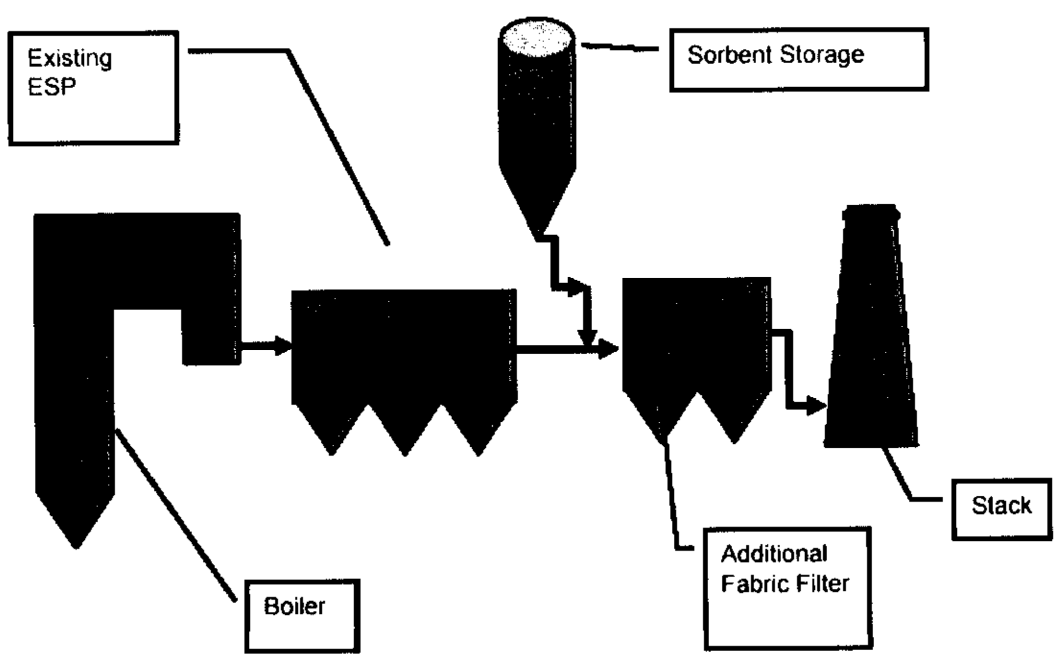



**Figure 8.7 Sorbent Injection in a TOXECON Arrangement**



The sorbent injection hardware does not take up much space and is relatively easy to retrofit onto an existing plant. Figure 8.8 shows a photo of the equipment used at one coal-fired power plant. The size of the storage silo is relatively small compared to existing APC equipment. Except in the case of TOXECON, it is not necessary to make any major alterations to ductwork or existing equipment when installing a sorbent injection system.

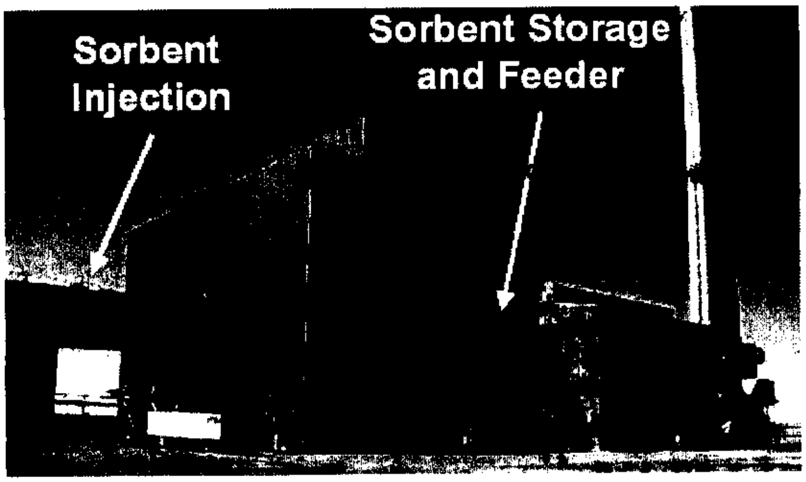



**Figure 8.8** Sorbent Injection equipment compared to other air pollution control equipment (Durham, 2005).

Although the equipment used for injecting sorbent into the flue gases of coal-fired power plants is essentially the same as that used at waste incinerators, significant differences in gas conditions exist between these two applications. In the case of MWCs, the concentrations of mercury and chlorides are typically much higher and the concentration of $SO_2$ is often lower. Gas temperatures at the sorbent injection point are often lower as well. For these reasons, gas conditions for high mercury capture efficiency using PAC are better in MWCs. Therefore, the air pollution control industry has developed new sorbent materials that are optimized for application in coal-fired power plant flue gas and generally perform better than the PAC sorbents that are used in MWC combustors and for other industrial applications. In recent years, the most widely tested of these are halogenated PACs offered by Sorbent Technologies (Twinsburg, OH) and NORIT (Marshall, TX/Borne, Netherlands).

### 8.4.1 Early Field Testing Experience with Sorbent Injection

Experience controlling mercury emissions from coal-fired boilers has been gained through laboratory and pilot testing programs that have led to numerous field test programs conducted to test sorbent injection systems on the flue gas of coal-fired electric power plants.

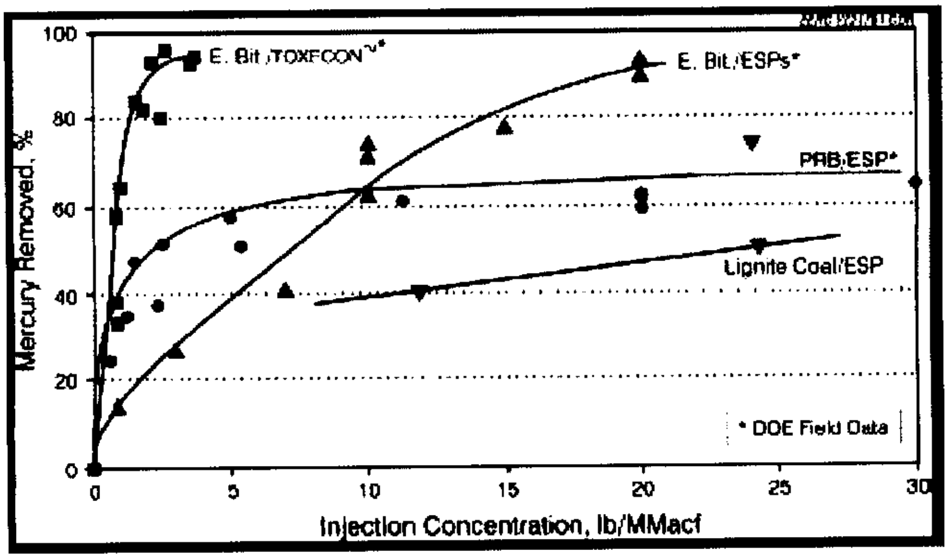
Figure 8.9 shows the results of some early full-scale field tests using untreated PAC sorbent. Mercury removal resulting from the PAC injection (this is the percent removal of mercury remaining after co-benefit removal) is plotted against the injection concentration of the sorbent measured in pounds of sorbent per million actual cubic feet of flue gas (lb/MMacf). These parametric tests showed the following:

- Based upon experience at Southern Company's Gaston Plant, high levels (over 90%) removal are achievable over short periods on bituminous coals with untreated PAC when a fabric filter was used to capture the PAC in a TOXECON arrangement.
- Based upon pilot testing at Public Service of Colorado's Comanche Station, high levels (over 90%) removal are achievable over short periods on bituminous coals with untreated PAC when a fabric filter was used to capture the PAC and there is not an upstream spray dryer absorber.
- Based upon experience at New England Power's Brayton Point Power Plant, high levels of mercury removal (90%) are achievable over short periods on boilers firing low sulfur bituminous coals with untreated PAC through in-flight capture, but at very high PAC injection rates.
- Based upon experience at WE Energies Pleasant Prairie Power Plant, high levels of mercury removal (90%) are not achievable over short periods on boilers firing subbituminous coal with untreated PAC through in-flight capture.

This early experience raised serious questions regarding the ability to achieve high mercury removal rates on units firing subbituminous coals using untreated PAC – where coal chlorine content is often very low (often under 50 ppm). Testing at other units firing low-rank coals (subbituminous or lignite), which tend to have low halogen content showed similar behavior when untreated PAC was used as the sorbent. Although lignite coals are not used in Illinois, methods used to solve the problem of low halogen content with lignite coals are applicable to subbituminous coals as well.

Since these early tests were short-term parametric tests, they also left questions regarding the long-term performance of these technologies that were to be addressed in future testing.

**Figure 8.9 Early Parametric Field Testing Results for Mercury Control by Untreated PAC Injection.**




### 8.4.2 Results of Additional Field Testing

Since the first field test programs of PAC performed in 2001(Bustard et al., 2001) the focus of additional testing has been on unanswered questions from the initial tests, new sorbents, and on other applications not addressed in the initial tests. Table 8.1 lists several of these test programs. These tests have shown that low-rank coals (lignite and subbituminous) have similar challenges with regard to mercury removal by sorbent injection. As a result, lessons learned in lignite test programs have been shown to be useful for subbituminous applications, and vice-versa.

Chemically treated sorbents manufactured by Norit and Sorbent Technologies have been developed to overcome the shortcomings of untreated PAC in low-rank coal applications. Field tests have been performed at numerous plants (*see* Table 8.1 below) with halogenated sorbents to compare their performance for mercury removal to that achieved with untreated PAC in the early

**Table 8.1 Sorbent Injection Field Demonstrations (*Durham 2005, Nelson 2005, Kang et. al. 2005, Tran et al. 2005*)**

| Station | Coal | Equipment | Notes |
|---|---|---|---|
| Gaston (1month) | Low-S Bit | FF | complete |
| Pleasant Prairie | PRB | CS-ESP | complete |
| Brayton Point | Low-S Bit | C-ESP | complete |
| Abbott | High-S Bit | C-ESP/FGD | complete |
| Salem Harbor | Low-S SA Bit | C-ESP | complete |
| Stanton 10 | ND Lignite | SDA/FF | complete |
| Laskin | PRB | Wet P Scrbr | complete |
| Coal Creek | ND Lignite | C-ESP | complete |
| Gaston (1 year) | Low-S Bit | FF | complete |
| Holcomb | PRB | SDA/FF | complete |
| Stanton 10 | ND Lignite | SDA/FF | complete |
| Yates 1 | Low-S Bit | C-ESP | complete |
| Yates 2 | Low-S Bit | ESP/FGD | complete |
| Leland Olds | ND Lignite | C-ESP | complete |
| Meramec | PRB | C-ESP | complete |
| Dave Johnston #3 | PRB | C-ESP | complete |
| Leland Olds | ND Lignite | C-ESP | complete |
| Portland #1 | Bit | C-ESP | In progress or planned |
| Brayton Point | Low-S Bit | C-ESP | complete |
| 6 Commercial Tests | Low-S Bit | ESP | In progress or planned |
| Laramie River | PRB | SDA/ESP | In progress or planned |
| Conesville | High-S Bit | ESP/FGD | In progress or planned |
| DTE Monroe | PRB/Bit | ESP | complete |
| Antelope Valley | ND Lignite | SDA/FF | In progress or planned |
| Stanton 1 | ND Lignite | C-ESP | In progress or planned |
| Council Bluffs 2 | PRB | H-ESP | In progress or planned |
| Louisa | PRB | H-ESP | In progress or planned |

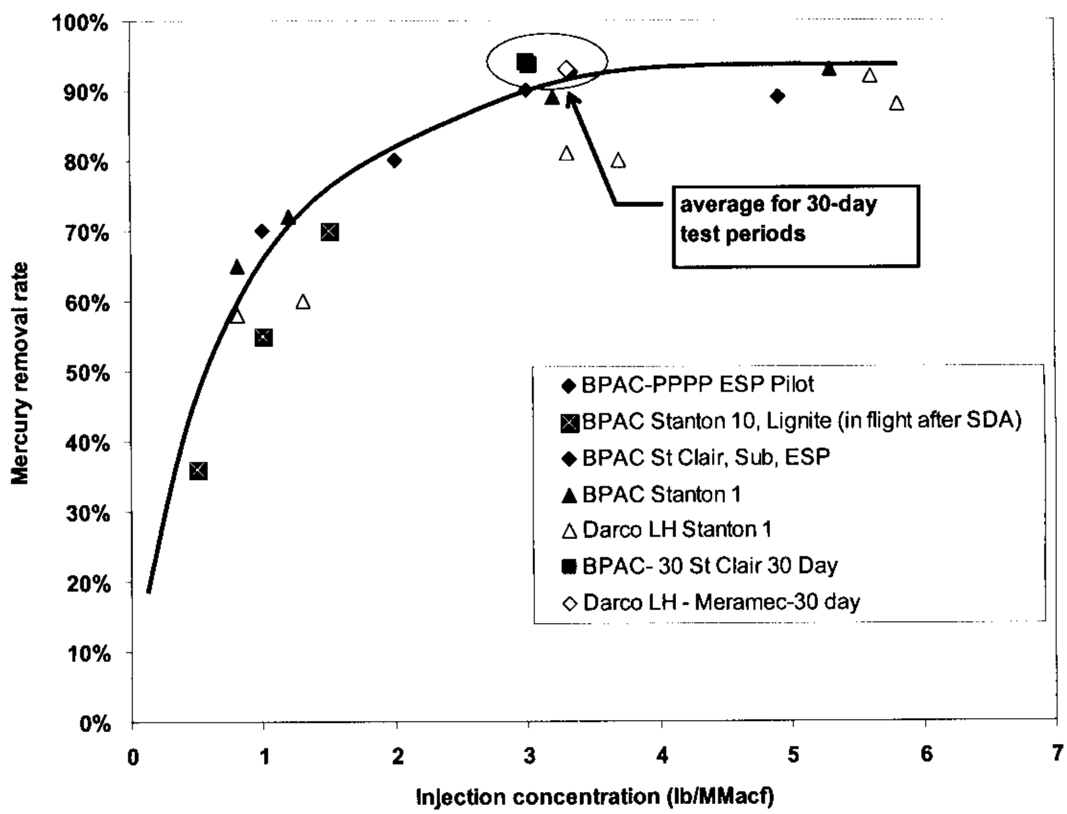
| | | | |
|---|---|---|---|
| Independence | PRB | C-ESP | In progress or planned |
| Gavin | High-S Bit | C-ESP FGD | In progress or planned |
| Presque Isle HS-ESP | PRB | ESP TOXECON | In progress |
| Allen Duke | Bitum. Low-S | CS ESP | complete |
| Lausche Ohio U | Bitum. High-S | CS-ESP | complete |
| Merrimack PSNH | Bitum. High SO3 | HS ESP | complete |
| Cliffside Duke | Bitum. Low-S | HS ESP | complete |
| Buck Duke | Bitum. Low-S | HS ESP | complete |
| St. Clair Detroit Ed. | Subbitum.Blend | CS-ESP | complete |
| St. Clair Detroit Ed. | Subbituminous | CS-ESP | complete |
| Stanton 1 GRE | Subbituminous | CS-ESP | complete |
| Stanton 10 | Lignite | SD/FF | complete |
| Stanton 10 | Lignite | CS-ESP | complete |
| Miami Fort | Bitum, Med S | CS-ESP | In progress |

tests for both bituminous and western fuels. Field test programs have also focused on long-term performance over periods extending to several weeks to as long as over a year.

### 8.4.2.1 In-Flight Mercury Removal

Figure 8.10 shows the in-flight mercury capture performance of halogenated PAC (B-PAC from Sorbent Technologies and Darco Hg LH from NORIT) at full-scale tests (and one pilot-scale test at the Pleasant Prairie power plant). Percent total mercury removal attributed to sorbent injection is plotted against the injection concentration of sorbent in pounds per million actual cubic feet of flue gas (lb/MMacf). Included in this data are results of two 30-day tests at St. Clair station and at Meramec Station. These two 30-day tests showed that over 90% mercury removal was achievable at sorbent injection rates near 3 lb/MMacf. These 30-day tests follow the trend of the parametric test data and even lie somewhat better than the trend of the parametric test data. The pilot test data from the Pleasant Prairie power plant (denoted PPPP ESP Pilot) is included because previous full-scale testing at Pleasant Prairie showed that only 60%-70% removal was possible with *untreated* PAC at injection rates as high as 12 lb/MMacf. These pilot results at

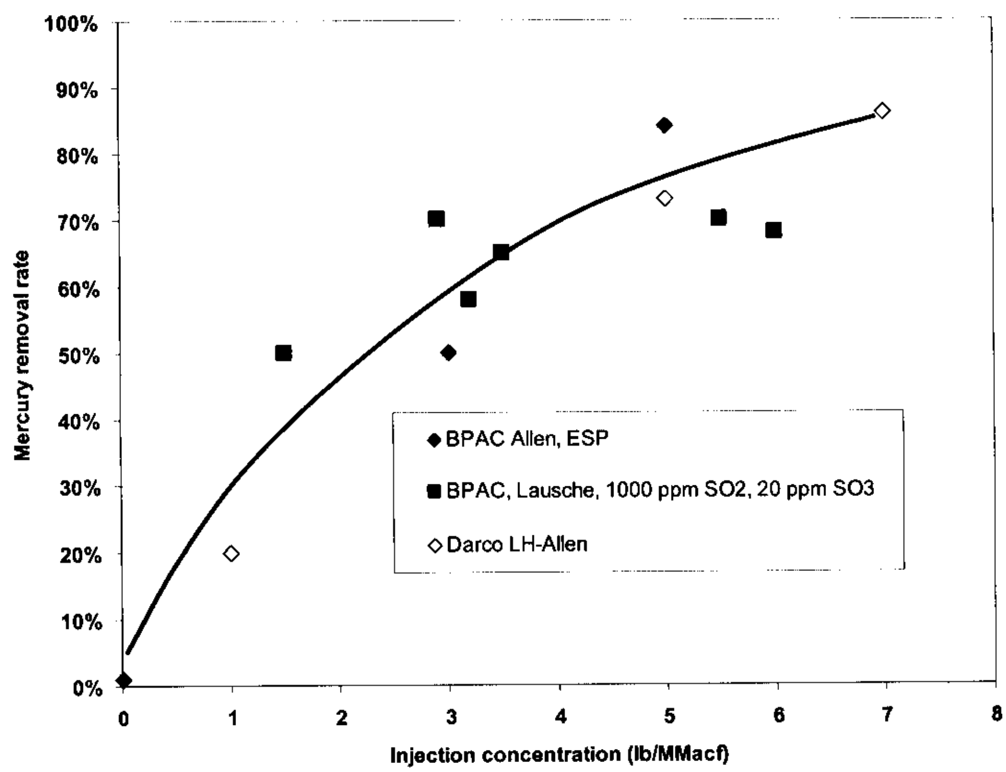
**Figure 8.10. In-Flight Mercury Removal Results of Full Scale Field Tests of Halogenated PAC Sorbent Injection on Low-Rank Coals (*Durham 2005, Staudt 2005, Nelson 2005*)**




Pleasant Prairie with halogenated PAC are completely consistent with the trend shown at other plants with halogenated PAC where 90% removal is achieved at around 3 lb/MMacf.

Although halogenated PAC sorbents were developed primarily to overcome the shortcomings of untreated PAC on boilers firing western coal, they have also been field tested on boilers firing bituminous coal with various sulfur levels. Untreated PAC is not effective when there is high coal sulfur content or particularly when there is a high $SO_3$ content in the flue gas. Figure 8.11 shows the results of the parametric testing of halogenated PAC at Lausche and Allen plants. The Allen plant is a low-sulfur coal application and Lausche Plant has a higher sulfur coal (although not as high a sulfur level as in most bituminous coals fired in Illinois). As shown, 90% removal is approached at injection rates of 7 lb/MMacf. There is currently no test data on units with sulfur levels as high as those of Illinois coals. Future testing is planned for higher sulfur applications (i.e., American Electric Power (AEP) Company's Gavin plant in Ohio) whose coal supply is similarof those in Illinois.

**Figure 8.11 In-Flight Mercury Removal Results of Full Scale Field Tests of Halogenated PAC Sorbent Injection on Bituminous Coals (*Durham 2005, Nelson 2005*)**




In-flight removal by sorbent injection has proven to be difficult for units equipped with hot-side ESPs. At these high temperatures (typically over 600 °F) the sorbent is not as effective. Nevertheless, testing of sorbents on units with hot-side ESPs has shown some promising results. At Duke Power's Cliffside and Buck Stations, which fire bituminous coals, 50%-70% mercury removal was achieved in short-term tests using a specially formulated halogenated PAC. Additional testing of advanced sorbents is planned for 2006 on PRB units as well (Durham 2005, Nelson 2005).

### 8.4.2.2 TOXECON and Fabric Filters

Except on western coals downstream of a Spray Dryer Absorber, PAC (untreated or halogenated) in TOXECON arrangements or fabric filter arrangements is generally accepted to be capable of over 90% removal because the sorbent is in very intimate contact with the gas stream as it passes through the filter cake of the fabric filter. Numerous full-scale and pilot tests, some extending over one year in duration, have confirmed these results. Issues regarding TOXECON relate largely to cost and to design issues relating to the fabric filter. Cost will be addressed in the next section.

The long-term field tests at Southern Company's Gaston Station addressed some of the TOXECON fabric filter design issues as they relate to fabric filter sizing and the fabrics that are best suited for this type of installation. It is important to note that the fabric filter at Gaston station was originally designed to capture only the small amount of fly ash that escapes the hot-side ESP, not the additional sorbent material that is introduced for capturing mercury. Therefore, when introducing sorbent the cleaning frequency of the fabric filter at Gaston increased to the point where damage might have occurred to the cloth filter bags over an extended time. For this reason the long-term test could not be performed at 90% mercury removal, but did achieve an average removal of 85% over the long-term test. As shown in Table 8.2, short-term tests at a simulated air-to-cloth ratio of 6.0 resulted in mercury removal as high as 97% while maintaining cleaning frequency below the limit of 1.5 pulses/bag/hour and using untreated PAC (DOE/NETL 2005).

**Table 8.2. Short-Term Test Results at Gaston Under Simulated Air-to-Cloth Ratio of 6.0** ***(DOE/NETL 2005)***

| Injection Rate (lb/h) | Injection Concentration (lbs/MMacf) | Inlet Hg Concentration (µg/Nm3) | Outlet Hg Concentration (µg/Nm3) | RE (%) | Cleaning Frequency (pulses/bag/hour) |
|---|---|---|---|---|---|
| 20 | 0.9 | 20.6 | 3.2 | 84.2 | 0.6 |
| 45 | 2.0 | 22.2 | 1.0 | 94.6 | 0.8 |
| 70 | 3.3 | 21.4 | 0.61 | 97.1 | 1.4 |

The following was a conclusion of the one-year test program of TOXECON at Southern Company's Plant Gaston (Berry et al., 2004).

- "TOXECON units designed at lower air-to-cloth ratios than COHPAC units are capable of high, 90%, mercury removal. For TOXECON baghouses, it is recommended that the maximum design gross air-to-cloth ratio be 6.0 ft/min."

### 8.4.3 Costs of Sorbent Injection Systems

#### 8.4.3.1 Capital Costs

The sorbent injection systems themselves – sorbent storage equipment, metering valves, pneumatic conveying system, injection piping, controls and associated installation and startup costs - cost in the range of $2/KW (somewhat higher for small units and somewhat lower for very large units), or about $1 million for a 500 MW plant. This is based upon estimates from technology suppliers, the U.S. EPA, and the U.S. DOE (Nelson 2005, Staudt et al. 2003, Srivastava et al. 2000). By comparison, an SCR system at a typical cost of $100/KW might cost around $50 million for the same 500 MW plant.

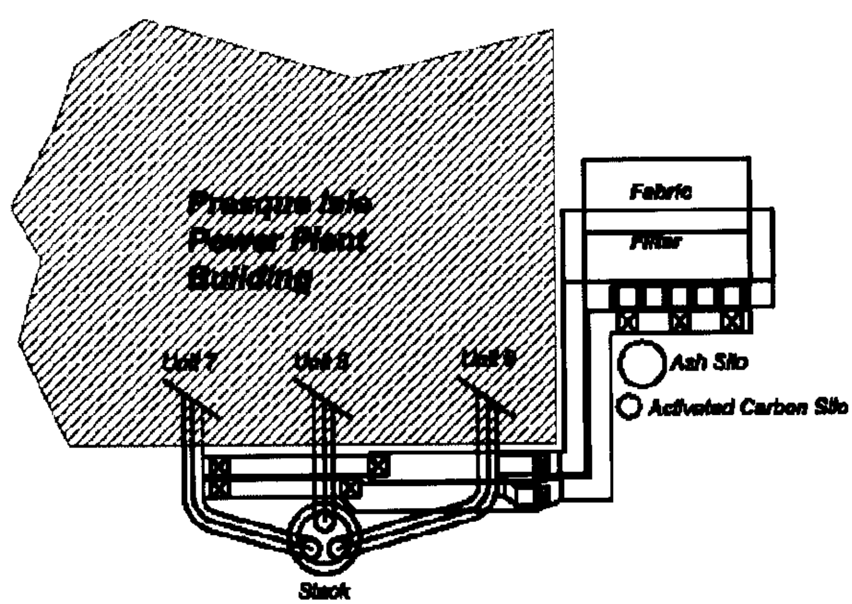
However, if a TOXECON system is necessary the capital costs will be much higher than a simple sorbent injection system, typically in the range of about $40-$60/KW due to the need to install a fabric filter system (Staudt et al. 2003). However, it is possible for the cost of a TOXECON system to be much higher in unusual circumstances. For example, at the U.S. DOE TOXECON demonstration program at WE Energies' Presque Isle power plant in Marquette, MI, the project entailed installing a single fabric filter on three small (~90 MW each) units. A long, complex, duct arrangement (see Figure 8.12) to and from the fabric filter was required due to inadequate space near the stack – where the fabric filter would have ideally been located with shorter, simpler, duct runs. For that reason the project capital cost was roughly double what would have been expected. In fact the cost estimate of the TOXECON system for the Presque Isle plant shows that the costs of structural steel and the mechanical and structure installation were more than the supply and erection of the key component – the fabric filter (Johnson et al., www.netl.doe.gov). So, depending upon the situation, the retrofit cost of a TOXECON might be higher than what is expected for most plants.

### 8.4.3.2 Operating Costs

For simple sorbent injection systems the largest operating cost is sorbent. There are costs associated with the power to run the pneumatic conveying system and the controls, but these are usually small compared to the sorbent cost. There are maintenance costs, but as the sorbent injection system is relatively simple, these are modest as well.

For a TOXECON system, sorbent cost will be lower since the sorbent is more efficiently utilized. However, the pressure drop across the fabric filter and the maintenance cost for the fabric filter result in higher operating and maintenance costs.

**Figure 8.12. Configuration of the TOXECON system at the Presque Isle Plant in Marquette, MI (Johnson et al., www.netl.doe.gov)**




Halogenated PAC sorbent currently costs in the range of \$0.75 to \$0.85/lb, depending upon source and shipping costs, etc. Untreated PAC sorbent costs about \$0.50/lb. Using a cost of \$0.80/lb of sorbent, the treatment rates of Figures 8.10 and 8.11, a gas flow rate of about 3,700

ACFM/MW for bituminous coal and 3,860 ACFM/MW for subbituminous coal, and heat rate of 10,500 BTU/KWhr, the control cost for sorbent (in $/MWhr or mills/KWhr) is shown in Figures 8.13 and 8.14 for subbituminous and bituminous coal fired boilers respectively. The contribution of capital cost to generation cost for a simple sorbent injection system ($2/KW) at a capacity factor of 80% and capital recovery factor of 14% is only about $0.04/MWhr – almost negligible compared to the effect of sorbent cost.

**Figure 8.13 Estimated Cost Impact to Generation of Sorbent for Mercury Removal on a subbituminous coal-fired boiler using halogenated PAC**

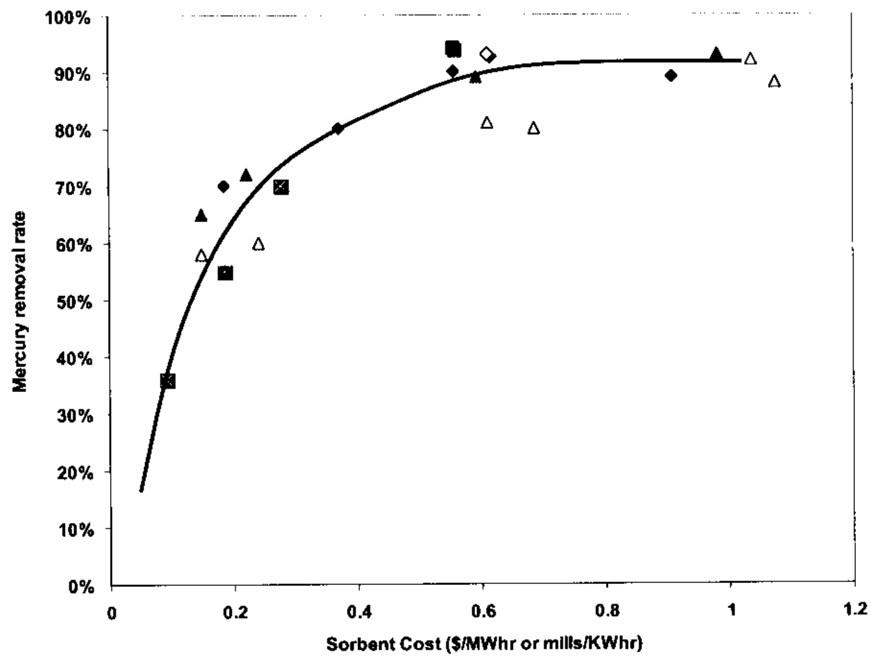
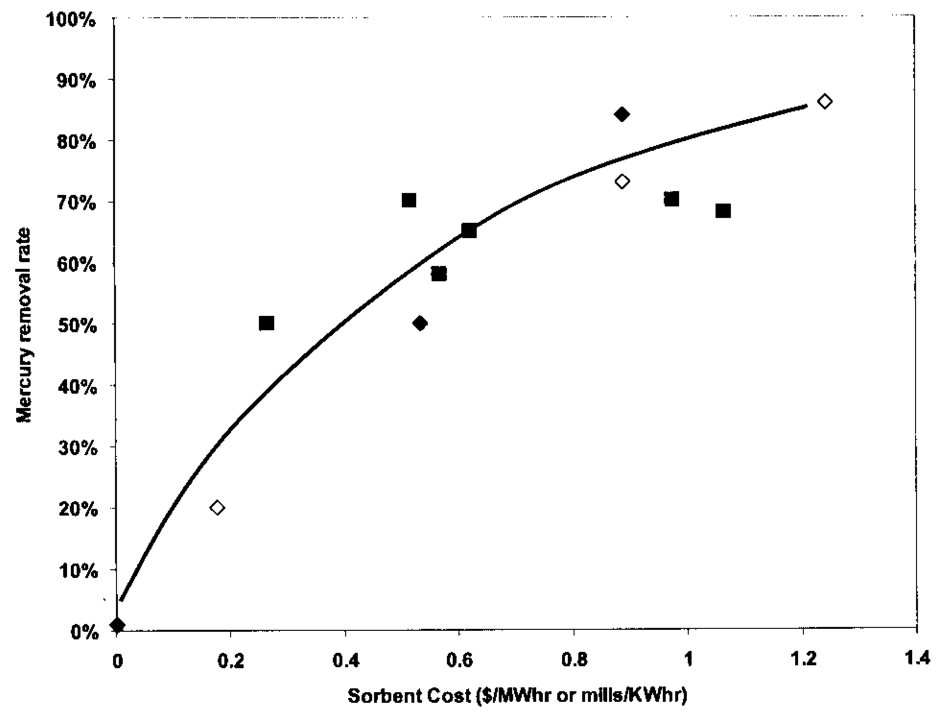


**Figure 8.14 Estimated Cost Impact to Generation of Sorbent for Mercury Removal on a Bituminous Coal-Fired Boiler using Halogenated PAC**




For a TOXECON system the sorbent cost will be significantly less but the capital cost will be much higher. At a capital cost of $50/KW and 80% capacity factor and 14% capital recovery the impact to generation cost is about $1/MWhr. At a cost of parasitic power (mostly from increased fan load) of $30/MWhr, and pressure drop of 8 inches of water column, parasitic power cost is estimated at $0.17/MWhr and other O&M (excluding sorbent, such as bag replacement and equipment maintenance) is expected to total about the same amount. Hence, before sorbent costs the total cost impact is about $1.34/MWhr (or 1.34 mills/KWhr) (Staudt et al. 2003).

Assuming an injection concentration of untreated PAC at 2 lb/MMacf for 90% removal with a cost of $0.50/lb and a gas flow rate of 3,860 ACFM/MW, the cost impact of sorbent is $0.23/MWhr (or 0.23 mills/KWhr).

For a TOXECON arrangement capital cost is higher than operating cost and has the most cost uncertainty. Therefore, TOXECON is not likely to be selected by a power plant for mercury control if a simple sorbent injection system will provide adequate removal unless there are other reasons to install the fabric filter. At this point in time, however, TOXECON is the only approach that has demonstrated a capability to achieve 90% removal on units equipped with hot-side ESPs. Notably, Illinois has only three EGUs with hot-side ESPs, Midwest Generation's Waukegan 7 and Will County 3 and Dynegy's Havana unit.

### 8.4.4 Balance of Plant Issues

Because of the newness of mercury control technology for coal-fired boilers, there are issues of concern to the power plant industry that are explored below.

#### 8.4.4.1 Impact on Other Equipment

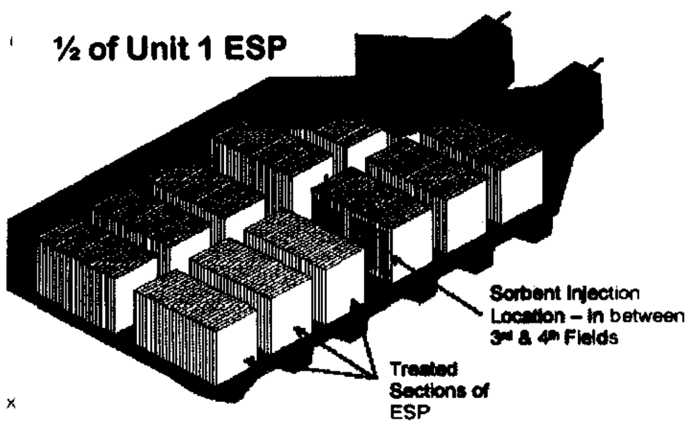
Sorbent injection has the potential to impact downstream equipment, especially the PM control devices such as the ESP or the FF. For an ESP, additional material has the potential to influence the capture efficiency of the ESP.

There have been dozens of test programs where sorbent was injected upstream of an ESP. Of these, only at Southern Company's Plant Yates (Dombrowski et al. 2004, 2005) and Great River Energies' Coal Creek Plant (Starns et al. 2004) have any adverse impacts been observed. At Southern Company's Plant Yates, which fires eastern bituminous coal, the ESPs are very small (Specific Collection Area (SCA) =173 $ft^2$/1000ACFM for Unit 1 and 144 $ft^3$/1000ACFM for unit 2). During testing these units experienced an increase in arc rate and a slight increase in particulate matter out while injecting untreated PAC at rates up to 12 lb/Mmacf.. At the Coal Creek plant, which fires North Dakota Lignite, a TOXECON II system was installed on an ESP with an SCA of 599 $ft^2$/1000 ACFM. The sorbent was injected between fields 3 and 4 as shown in Figure 8.15. Untreated PAC sorbent was also used in this field test and therefore sorbent injection rates were quite high (up to 12 lb/MMACF). Particulate emissions from the ESP increased during periods of carbon injection from an average of 0.027 gr/dscf to an average of 0.054 gr/dscf.

The tests at Yates and Coal Creek that showed some impact on the ESP were performed with untreated rather than halogenated PAC. Halogenated PAC would have significantly reduced the sorbent injection rate at any given removal level and would likely have reduced, if not eliminated, the adverse impacts to these plants. There have been dozens of field test where sorbent was injected to control mercury emissions and, other than these two tests there have been no tests where ESP performance was reported to be adversely impacted.

To date there have been no reported impacts on equipment corrosion or erosion, plugging or any other adverse effect on downstream equipment.

**Figure 8.15 TOXECON II Arrangement at Coal Creek Plant (Starns et al. 2004)**




For units equipped with fabric filters downstream of the sorbent injection system, no problems have been observed or are expected for fabric filters designed to collect the full boiler fly ash stream. Sorbent will only increase the mass loading of the fly ash by at most a few percent and often by less than one percent. The experience at Gaston showed that for fabric filters installed downstream of ESPs (designed for lower particulate loading), the air-to-cloth ratio should remain under 6.0.

### 8.4.4.2 Environmental Impact of Sorbent Disposal

There have been numerous tests of both untreated and halogenated PAC sorbents to determine if toxic materials leach from these sorbents. Leaching studies have been conducted on the spent sorbent on most of the tests conducted to date. All have shown that any leached material is well below U.S. EPA guidelines with most below the detectable limit of 0.01 $\mu$g/liter. Therefore, the mercury appears to be tightly bound to the sorbent and there is no reason to believe that fly ash that is otherwise non-hazardous may be reclassified as a hazardous material as a result of sorbent injection.

### 8.4.4.3 Impact on Coal Combustion Product Utilization

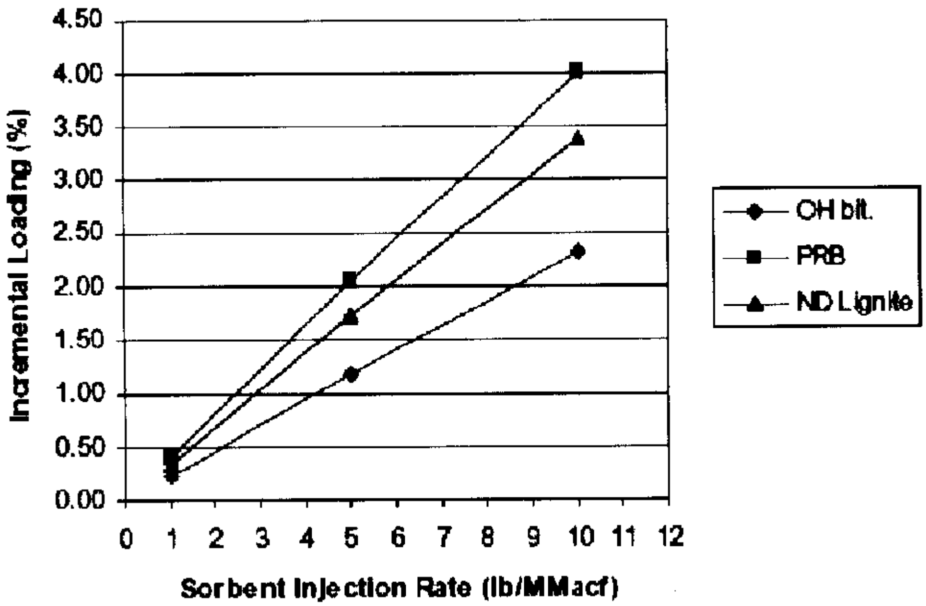
Fly ash is an inexpensive replacement for portland cement used in concrete, while it actually improves strength, segregation, and ease of pumping of the concrete. Fly ash is also used as an ingredient in brick, block, paving, and structural fills. However, concrete is the most valuable use. About 20% of the fly ash from U.S. coal fired power plants is sold to the cement industry. The value of the fly ash as a concrete additive is determined by its mineral constituents, the impurities present (such as unburned carbon from the coal), and other properties. The ASTM has maximum allowable standards for accepting coal fly ash with carbon in it for specific purposes. However, this normally is not the limiting criteria. Carbon (especially activated carbon) absorbs an Air Entrainment Admixture (AEA) that is added to cement to control cement strength.

Figure 8.16 shows the estimated carbon contribution to fly ash at a range of injection rates. At these injection rates, which are well below those of Figures 8.10 or 8.11, the carbon content remains well below the ASTM limit (6% per ASTM C-618).

If the fly ash that was otherwise sold for cement purposes is no longer marketable for cement purposes, the cost impact to generation will vary depending upon.

- The amount of fly ash that is being generated at the power plant (which depends on coal ash content, heating value and unit heat rate, etc.)
- The marketable value of the ash as a cement material
- The marketable value of the ash for lower quality applications
- The cost to dispose of the ash, if necessary

**Figure 8.16 Estimated Carbon Content in Fly Ash for different Coals and Injection Rates (Nelson, 2005)**




Depending upon these factors, the effect could potentially be quite significant – up to about 1 mill/KWhr. Therefore, there is a great deal of effort being expended to address this potential concern.

To address the problem with the effects on the cement AEA additive, there are several possible solutions:

- Separation of the carbonaceous portion of the fly ash from the mineral portion. The mineral portion may be sold and the carbonaceous portion disposed, which would require equipment for separation and material handling.
- Another promising technique being examined by the Electric Power Research Institute (EPRI) and U.S. DOE is ozone passivation (Hurt et al., www.netl.doe.gov). Passivating the fly ash will neutralize the sorbent properties that impact the AEA additive. Cement grade ash that has 6% carbon can still be marketed for cement purposes.
- High carbon fly ash may actually be used in the cement kiln, as has been done at Illinois Cement Company, located in LaSalle, Illinois, using a high-carbon fly ash

from Coffeen Power Station. Using high carbon fly ash, the cement plant achieved fuel savings of approximately 3.9%, the production increased by approximately 9.7%, and several key processing parameters were improved Illinois Clean Coal Institute (ICCI), www.icci.org/oofinal/bhatty99.htm.

- Sorbent Technologies has an approach for making their sorbent "cement friendly". This sorbent material has been successfully demonstrated to remove mercury effectively (similar effectiveness as their brominated PAC) and to produce a low "foam index" – a measure of the effect on the AEA additive – that leaves fly ash marketable for cement purposes.
- Finally, Engelhard (Iselin, NJ) is developing a mineral-based sorbent that will not have any impact on the fly ash. In fact, they are also able to take fly ash, chemically treat it, and use it as the sorbent material. This is a new technology and the first full-scale 30-day test of a mineral sorbent is currently in progress at the Cinergy Miami Fort Plant in Ohio (Hutson, 2005).

#### 8.4.4.4 Environmental Impacts of Brominated Sorbents

Bromine is an ozone depleting agent and can also contribute to the formation of toxic materials in combustion systems. Studies have shown that the bromine remains adhered to the carbon and is not emitted to the atmosphere. With regard to toxic emissions, testing was performed by U.S. EPA at two units, one with a CS-ESP and the other with a HS-ESP, to determine if polychlorinated dibenzo-p-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) or polybromininated dibenzo-p-dioxin (PBrDD) and polybrominated dibenzofuran (PBrDF) are formed when brominated PAC is injected. Tests showed that they do not appear to be formed, and if any may be formed, they are well below the limits established by U.S. EPA for these materials (Hutson 2005).

#### 8.4.4.5 Impacts on Selective Catalytic Reduction

If PAC is injected prior to an SCR, which is possible in a hot-side ESP arrangement, no impact is expected on the SCR because: 1) the PAC is captured in the hot-side ESP prior to the SCR; and

2) carbon has no negative impact on SCR catalyst. SCR catalyst is designed to accommodate some fly ash build up, and the fly ash has some carbon in it. Therefore, any injected PAC that manages to escape the hot-side ESP will not have an impact on the SCR.

#### 8.4.4.6 Performance Over Various Temperature Ranges

Untreated PAC is known to loose much of its mercury sorbert capacity at temperatures greater than about 325 °F. Therefore, for those units with CS-ESPs that operate at or above that temperature, untreated PAC may perform very poorly in capturing mercury. On the other hand, halogenated PAC has been shown to be effective over a much wider range of temperatures. At temperatures in the range expected for CS-ESPs (up to around 400 °F), little or no change in performance is expected. Only at very high temperatures typical of a HS-ESP would a significant performance shortfall be anticipated.

### 8.4.5 Issues Relating to Commercial Availability and Impact to the Utility Sector

There are a number of issues that were raised during outreach meetings with the power industry regarding the potential impact to plant reliability and whether mercury control technologies are commercially available. This section will discuss the various issues raised under this general category.

#### 8.4.5.1 Time and Materials to Engineer, Procure Install Sorbent Injection Systems

Sorbent injection systems can generally be fully installed and commissioned within about six months from a power plant placing an order. This includes engineering, procurement, installation and start up. Because the equipment required is not very specialized (silo, feeder valve, blower, piping, and controls), the equipment is readily purchased from a number of suppliers. Interface with the boiler system involves installation of penetrations for injection piping. These can normally be installed over an outage of a few days. Therefore, there should be no impact to the operation of the plant for a simple sorbent injection system.

In the event a fabric filter system is installed as part of the mercury control system, engineering, procurement and installation will take longer (likely over a year) and will require more extensive outages. The Presque Isle program was planned to be just under two years from start of design to completion of start up (March 2004 to January 2006) (Johnson et al., www.netl.doe.gov). Considering the complexity of that particular installation, most systems would likely take less time.

Installation of mercury control equipment can be performed during a planned outage of the unit boiler. When air pollution control equipment such as a fabric filter is added, outages are only necessary when existing ductwork is altered. This way the equipment can be erected with the boiler on line and outage time is minimized. In some cases, especially if a bypass is available, the outage can be taken early in the project and any later outage, if needed, can be of a very brief duration. So, even if a TOXECON system is installed on a boiler, it is expected to have little or no impact to unit availability.

#### 8.4.5.2 Guarantees

Guarantees are a subject that is raised by industry when "Commercial Availability" is discussed. According to the Institute of Clean Air Companies, pollution control equipment suppliers are currently offering mercury control technologies with commercial guarantees on performance (ICAC 2004).

While the specifics of the guarantees in any contract are negotiated between supplier and buyer, these guarantees typically include a guarantee on the pollutant removal performance of the technology (under specified process conditions), the usage rates of consumables (such as sorbent feed rate and power), and remedies to address any shortcomings in performance. The following is part of the guarantee wording taken from a portion of a proposal from Sorbent Technologies (Nelson, 2005). As shown, the guarantee language stipulates a required performance at a particular sorbent feed rate under specified conditions. (Nelson, 2005)

**PERFORMANCE GUARANTEES**

> Sorbent Technologies will guarantee the more restrictive of ninety (90) percent removal or to a level of $20x10^{-6}$ lb of Hg/MWH of total mercury in the flue gas using brominated B-PAC™ powdered activated carbon at a rate not to exceed 230 lbs/hr based on the design flow rate of about 1,535,000 ACFM for each boiler. The removal rate is from the air preheater outlet to the stack. The mercury removal guarantee is valid only when the units are firing the coals described in the Customer Specification, when the air heater outlet flue gas temperatures are maintained at below 370°F, when the fabric filters are operating properly, and when the relative SO3 mass flow rates at the air preheater are no greater than that specified. If no certified continuous mercury emissions analyzers are available, compliance shall be determined by others using certified CEMs or another method as determined by the March 15 utility mercury regulation. This guarantee shall be met according to page D-4 of Schedule D.

Normally, the liability to the vendor to remedy a performance shortfall as specified in the performance guarantees is limited to an amount that is related to the cost of the project. This is typical for all air pollution control equipment guarantees and for other types of guarantees or warranties in general. These guarantees are currently offered by suppliers of mercury control technology, although the specifics of their guarantees may differ because they are negotiated with the buyer.

Consequential damages are associated with a power plant's lost profits that may result from the lost revenues and increased costs that may result from an unplanned outage or a reduction in plant output. Because these consequential damages have the potential to be many times greater than the cost of the pollution control equipment, consequential damages are rarely included in a contract. This is very similar to the fact that the electric company will not reimburse a business for lost profits during a power shortage. In order to accept such a potentially unlimited liability for the small profit of selling electricity, the electric company would have to make the electricity very expensive. The same holds true for pollution control equipment. And, therefore, consequential damages are rarely, if ever, included in a contract. In some cases liquidated damages may be agreed to. However, these are normally a fixed amount associated with time out of service up to a total amount of limited liability.

### 8.4.5.3 Supply of Sorbent

Activated carbon sorbents are available from a number of suppliers, including Norit, Calgon, HOK and several other companies. Halogenated (particularly brominated ) activated carbon sorbents are available from Norit and from Sorbent Technologies. The halogenated sorbents are manufactured from an untreated carbon that is treated with bromine or another halogen. Treatment of the sorbent is a relatively simple process that can be scaled up quickly. These companies have committed to increasing the supply of halogenated sorbents to meet the market needs. The availability of activated carbon is high at this time. There is currently an oversupply of carbon in the U.S. that is compounded by oversupply worldwide because there was a period of overbuilding of capacity in the 1990s. If demand did grow to the point where supply had to be increased, it would take 2-3 years to add a plant (EPA-600/R-02/073, 2002). Therefore, there is plenty of capacity of PAC for Illinois power plants and if demand throughout the U.S. increases to where more capacity is needed, it can be built in time to meet demand.

### 8.4.5.4 Long-Term Experience

Sorbent injection systems have been in operation on numerous MWCs for several years. Thus, experience with the equipment is well established. Questions therefore are associated with the ability of the sorbent to provide reliable mercury removal on a day-to-day basis in power plant flue gas applications.

As previously discussed, impacts to downstream fabric filters have been examined, especially for TOXECON arrangements. As a result of these studies, design parameters for TOXECON fabric filter systems have been developed to address these concerns.

In the configuration where halogenated sorbent is injected upstream of a cold-side ESP on a boiler firing subbituminous coal there have been several tests, some several weeks in length, with very consistent results – not only at the unit over the test period but also consistent when comparing different units. As a result, the confidence that the sorbent will perform as expected over the range of normal operation for these units is rather high. In fact, longer-term tests have shown better performance than short-term tests. Tests indicate that some of the PAC builds up over time on ductwork surfaces. While this PAC accumulates during short-term tests it is not contributing to mercury removal. But, over periods of several weeks when the PAC that is built up on duct surfaces and becomes re-entrained in the gas stream, it contributes to mercury removal. This explains why longer-term tests have shown better performance than short-term tests.

For less conventional applications, such as TOXECON II, there is far less data and there is reason to have some concern about the limitations of the ESP. Several test programs are underway to examine this potential issue.

Unlike SCR systems, where long-term catalyst activity is a serious concern, and unlike FGD systems where reliability of equipment in highly corrosive environments is a concern, sorbent injection systems use a material that is continually injected and has shown no tendency to corrode or degrade equipment. Moreover, there is no technical basis reason to believe it might induce corrosion. Therefore, many of the long term issues that existed for other air pollution control technologies do not exist to any great extent with sorbent injection.

### 8.5. Other Emerging Control Technologies

This Section focused primarily on technologies that are available in the near term and are most likely to be deployed by Illinois power plants. But, there are technologies that are emerging quickly and which could address some of the concerns with existing available controls.

#### 8.5.1 Improved Sorbents and Sorbent-Related Technology

Work is underway to develop improved mercury sorbents that overcome some of the shortcomings of existing PAC and halogenated PAC sorbents. These include:

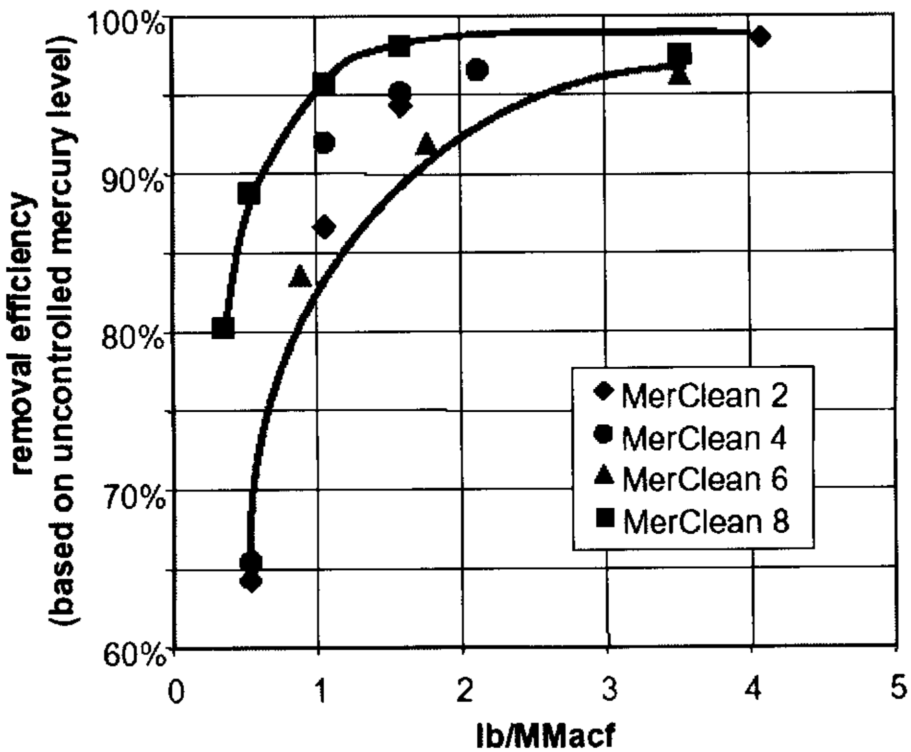
- PAC-based sorbents designed for high temperature applications that may make high removal rates possible from boilers with hot-side ESPs without the need for a TOXECON system.

- PAC-based sorbents designed for high sulfur coal applications that can provide high removal efficiencies at low treatment rates.
- Mineral-based sorbents that utilize either treated clays or treated coal fly ash to capture mercury. This sorbent is being developed by Engelhard Corporation and also Amended Silicates Corporation and is being tested at the full scale. The advantages of mineral-based sorbents potentially are: 1) lower sorbent costs since fly ash is "free" to a power plant; 2) no adverse impact to fly ash marketability; and 3) potentially higher temperature applications.
- Chemical additives for the fuel or ductwork that improve sorbent utilization and combinations with advanced sorbents, such as mer-cure technology from ALSTROM, which was tested as PacifiCorp's Dave Johnston Unit #3 in Wyoming to achieve well over 90% removal as shown in Figure 8.17.
- Passivation technology that mitigates the effect activated carbon has on the AEA additive for cement. Fly ash with a small amount of activated carbon can be treated and then used as a high value cement additive.

### 8.5.2 Advanced Fuel Beneficiation

KFX (Denver, CO) offers K-Fuel that thermally treats otherwise unmarketable subbituminous coal to increase the heating value and to reduce the emissions when the fuel is burned. KFX has shown high mercury removal rates of about 70% with KFuel. Through the use of a treated coal such as KFuel, it would be easier to meet the output-based standard in the proposed rule.

**Figure 8.17. Preliminary Data Demonstrating Mercury Control Performance of Mer-Cure™ystem Collected at Dave Johnson Unit 3 During Parametric Testing (Srinivasachar, 2005)**




### 8.5.3 Multipollutant Controls

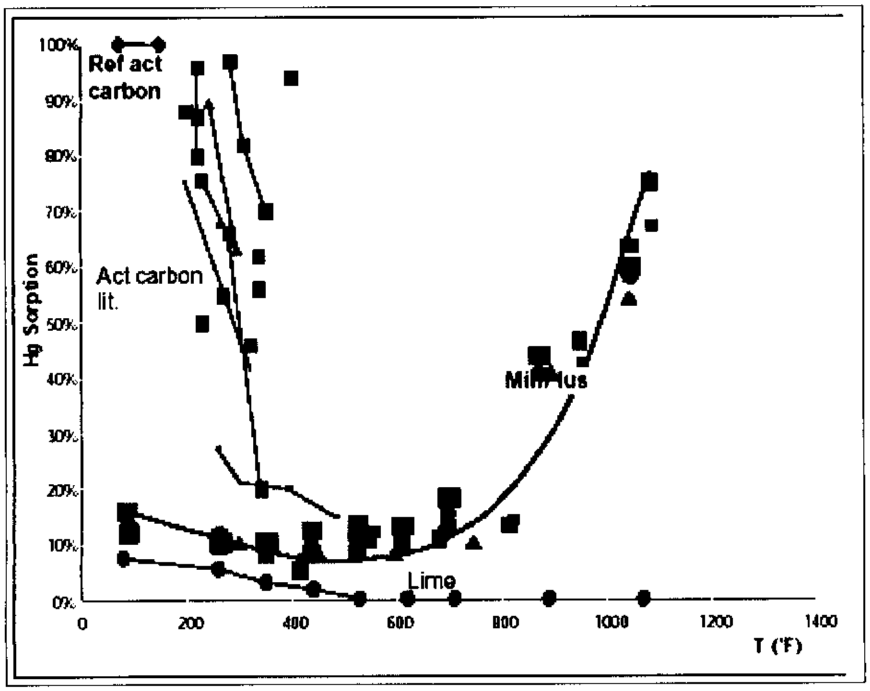
Currently, there are a number of multipollutant controls that are being commercially deployed that may also remove mercury. The following is an incomplete list:

- Electro-Catalytic Oxidation (ECO) is a multipollutant control technology that is being commercially deployed at First Energy's Bay Shore Plant in Toledo, OH, on 215 MW Unit 4. ECO has shown in a commercial scale demonstration that it is capable of high NOx, $SO_2$, and mercury removal.
- Mobotec's ROFA and ROTAMIX technology uses rotating overfire air (ROFA) to reduce NOx and also uses injection of NOx reducing reagents, $SO_2$ sorbents and mercury sorbents for reduction of NOx, $SO_2$ and mercury (ROTAMIX). ROFA and ROTAMIX are commercially deployed for NOx and $SO_2$ control. ROTAMIX is currently commercially deployed at the Dynegy's Vermillion power plant Unit 1 for NOx control.

Mercury control by ROTAMIX has been tested at full-scale in field trials. At Richmond Power & Light's Whitewater Valley Unit #2 in Richmond, IN, 98% mercury removal was achieved with MinPlus sorbent injected at about 2000 °F or more with injection rates of 10-20 lb/MMacf. Whitewater Valley Unit #2 is bituminous coal-fired unit with a CS-ESP that operates above 400 °F. Fixed bed laboratory tests shown in Figure 8.18 suggest that MinPlus mercury capture occurs above 1500 °F (Biermann et al., 2006). Therefore, this appears to be an approach that may be useful for boilers with hot-side ESPs without adding a fabric filter for a TOXECON arrangement.

- Enviroscrub's Pahlman process is a sorbent-based process for combined NOx, SO2, and mercury removal while using a regenerable sorbent. It is not commercially deployed at this time.

**Figure 8.18 Fixed Bed Laboratory Tests Comparing Hg Sorption by Various Sorbents (MinPlus Sorbent, 2005)**




## 8.6. Control Options for Coal-Fired Boilers in Illinois

This section describes the control options that appear to be available to Illinois coal-fired boilers.

### 8.6.1 Control Options for Boilers Firing Bituminous Coals

Air pollution control technologies at plants burning Illinois bituminous coal include:

- CS-ESP
- SCR+CS-ESP
- SCR+CS-ESP+wet FGD
- FBC+SNCR+FF

The units that have SCR and FGD as well as the unit with FBC + FF are likely already achieving relatively high levels of mercury removal and may already comply with 2012 requirements of the proposed rule. If not, these units may be able to come into compliance through optimization or addition of oxidizing chemicals to improve FGD capture efficiency. However, if additional mercury removal is required, sorbent injection can provide this additional removal at a reasonable cost because the incremental removal is likely to be quite low. Although untreated PAC has been shown to have poor effectiveness in removing mercury from the flue gas of high sulfur coal, tests with halogenated PAC sorbent injection technology indicate that this should provide the additional removal necessary for compliance.

The Coffeen and Hutsonville units are not likely to be achieving adequate mercury removal through co-benefits alone. However, 90% mercury removal is expected to be achieved through a combination of co-benefit optimization, and halogenated sorbent injection.

Under consent decree is Dynegy's Vermillion plant that has agreed to install a fabric filter and sorbent injection mercury control technology. Therefore, it will be able to achieve over 90% control of mercury through combination of the fabric filter and sorbent injection.

- For bituminous coal fired boilers equipped with SCR, ESP and FGD, 90% removal is achievable through co-benefit of these controls. Ninety percent (90%) removal, and close to it, has been measured at several facilities. Test programs with chemical additives to enhance oxidation have demonstrated an ability to improve mercury capture further. Therefore, additional mercury-specific controls are not likely to be necessary on such units. If additional controls are needed, low sorbent injection rates are anticipated due to the small incremental mercury removal needed.
- For bituminous coal fired boilers equipped with a cold-side ESP, with or without SCR, around 30% or more may be achieved through co-benefit. Additional mercury removal to 90% can be achieved by injection or halogenated sorbent.
- Mercury capture from a Circulating Fluidized Bed (CFB) boiler with a fabric filter firing bituminous coal is expected to be high – about 90% or possibly better. The Southern Illinois Power Cooperative's (SIPCO) CFB may also install a limestone spray tower, which will improve mercury control even further.

### 8.6.2 Control Options for Boilers Firing Subbituminous Coals

The subbituminous coal fired boilers in the State (including those that burn primarily subbituminous coal and a small amount of bituminous coal) generally have cold-side ESPs, with a small number of units equipped with hot-side ESPs. A few units have SCR as well. The units with cold-side ESPs can be effectively controlled to 90% removal with halogenated sorbent. However, the units with hot-side ESPs are a greater challenge because at this point in time TOXECON is the only control technology that has been shown to be effective in providing 90% or better control of mercury emissions on unscrubbed units equipped with hot-side ESPs. Dynegy's Havana unit has a HS-ESP & SCR, and is under consent decree to install a spray dryer absorber and fabric filler. These have been shown to provide a high level of mercury control over 90%. However, neither of Midwest Generation's two HS-ESP units, Will County #3 and Waukegan #7, is under any consent decree or any other requirement to install any additional air pollution control equipment. TOXECON, as noted earlier, is more costly than a simple SI system. ROTAMIX using the MinPlus sorbent may also prove to be an option for these units that is less expensive than TOXECON.

- For subbituminous coal fired boilers equipped with cold-side ESPs, 90% removal can be achieved with halogenated PAC at treatment rates in the range of 3 lb/MMacf. This has been achieved at several short-term parametric test programs and also for 30-day test periods. The consistency of these results at several test programs on low-rank coal increases the confidence that this method is likely to provide the high level of mercury reductions needed over long term operation.
- For units with HS-ESPs, TOXECON is currently the only proven technology for achieving 90% removal. Dynegy's Havana unit has a HS-ESP & SCR, and is under consent decree to install a spray dryer absorber and fabric filter. With sorbent injection in addition to the equipment required for the consent decree, high mercury removal over 90% can be assured. However, neither of Midwest Generation's two HS-ESP units, Will County #3 and Waukegan 7, are not under any consent decree or any other requirement to

install any additional air pollution control. Therefore, to achieve 90% removal at these units TOXECON is necessary but was not otherwise planned.

- For unscrubbed units with hot-side ESPs, TOXECON is the technology that is certain to be capable of providing 90% mercury removal. ROTAMIX with MinPlus sorbent may be an alternative. Another, more expensive, alternative to TOXECON is addition of a scrubber combined with use of oxidizing chemicals and/or coal blending and an SCR which could provide 90% removal. This approach would also provide NOx and $SO_2$ control benefits and may be considered by the owner or operator since its units must comply with the NOx and $SO_2$ reduction requirements of the Clean Air Interstate Rule.

Tables 8.3 and 8.4 shows the various fuel and APC equipment configurations and possible methods for achieving 90% mercury removal. With the exception of the units with hot-side ESPs, most units should be able to achieve 90% or better removal through optimization of co-benefits, combination of co-benefits with halogenated sorbent injection, or through halogenated sorbent injection alone. Therefore, most units are capable of achieving 90% mercury removal with a relatively small capital expenditure.

The units with hot-side ESPs pose a more difficult challenge. The current sorbent technology that is known to be capable of achieving 90% removal from subbituminous units with hot-side ESPs is the TOXECON arrangement. Sorbent technology is improving and there have been some promising results on hot-side ESPs. TOXECON does provide air pollution control benefits beyond mercury control and should be considered for these benefits. However, ROTAMIX with MinPlus sorbent may be a promising alternative to TOXECON and has been shown to achieve over 90% mercury removal on a bituminous coal fired unit at high temperatures. Field testing on subbituminous coal has not yet been performed. ROTAMIX may also provide other pollutant control benefits, such as NOx and $SO_2$. Other approaches available to operators of these units include FGD retrofit with fuel blending, which would have $SO_2$ as well as mercury control benefits.

**Table 8.3 Summary of Boiler Types and Control Options for Bituminous Coal Fired Boilers**

| Coal Type | Existing Configuration | Hg Control Technology | Comments |
|---|---|---|---|
| Bituminous | SCR+ESP+FGD | Coal Cleaning | 90%+achievable |
| | | Co-benefit optimization | |
| | | Additives | |
| | CS-ESP | Coal Cleaning | Use in combination with sorbent injection |
| | | Co-benefit Optimization | |
| | | Halogenated PAC | 90% achievable |
| | SCR + CS-ESP | Wet FGD or Spray Drier & FF | 90% achievable |
| | HS-ESP | TOXECON | 90%+ achievable |
| | | ROTAMIX with Min Plus | 90%+ may be achievable |
| | | Halogenated PAC | 50%-70% achievable |
| | HS-ESP + SCR | Wet FGD or Spray Drier & FF | 90% achievable |
| | CFB + FF | Co-benefit optimization | 90% may already be achieved without additional controls |
| | CFB + SDA + FF | Co-benefit optimization | 90%+ achievable |

**Table 8.4 Summary of Boiler Types and Control Options for Subbituminous Coal Fired Boilers**

| Coal Type | Existing Configuration | Hg Control Technology | Comments |
|---|---|---|---|
| Subbituminous | CS-ESP | Fuel Blending (increase co-benefit) + Halogenated PAC | 90% achievable |
| | | Halogenated PAC | |
| | CS-ESP+SCR | Fuel Blending or oxidizing chemical + FGD | 90% achievable |
| | HS-ESP | Halogenated PAC | 90% not yet achieved |
| | | Fuel Blending ***and/or*** oxidizing chemical + FGD | 90% may be achievable |
| | | TOXECON | 90%+ achievable |
| | | ROTAMIX with MinPlus | 90%+ shown on bituminous, performance on subbituminous not yet known |
| | HS-ESP+ SCR | Halogenated PAC | 90% not achievable |
| | | Fuel Blending ***and/or*** oxidizing chemical + FGD | 90% achievable |
| | | ROTAMIX with MinPlus | 90%+ may be possible (impact to SCR needs to be examined) |
| | | TOXECON | 90%+ achievable |

## 8.7 Estimate of Cost of Mercury Control and Cost per Unit of Mercury Reduction

In estimating the cost of controlling mercury at Illinois power plants, we used fuel use data as reported in the Statewide Coal-Fired Electric Utilities Report, as Fly Ash and Bottom Ash Disposal Cost and Sales Revenue data per Energy Information Administrative (EIA) Form 767 data, and also fuel mercury data per the "Illinois Coal Properties in Regard to Mercury" PowerPoint presentation by Massoud Rostam-Abadi of the Illinois State Geological Survey, University of Illinois at Urbana Champaign at the ICCI Mercury Meeting, November 9, 2005.

Table 8.5 shows typical characteristics of the coals being fired, although it is understood that the actual characteristics at particular units will vary from this.

**Table 8.5 Typical Characteristics of Fuels Fired (2005, Massoud Rostam-Abadi)**

| Fuel Type | Heating Value (BTU/lb) | Hg Content of Coal | | |
|---|---|---|---|---|
| | | (mg/MMBtu) | lb/Tbtu | Hg, mg/kg |
| Bituminous Fuel | 11,613 | 3.1 | 6.83 | 0.08 |
| Subbituminous Fuel | 8,090 | 5.7 | 12.56 | 0.1 |

These fuel characteristics were used to estimate the mercury input into the plants and the emissions levels will be achieved after the addition of controls.

Using historical coal use (average of highest three years from 5-year look back) the fuel use and mercury in coal are projected in Table 8.6.

**Table 8.6 Projected Coal Use and Hg in Coal.**

| | Coal Use, 1000 tpy | Hg in Coal, oz |
|---|---|---|
| Bituminous | 6,689 | 17,125 |
| Subbituminous | 47,170 | 150,943 |
| Total | 53,859 | 168,068 |
| Note: columns may not add due to rounding | | |

Using the above table to estimate mercury emissions (which is only one of several methods). The proposed rule would result in statewide emissions from these units roughly at or below 16,693 ounces (calculated based on 10% of an "average" bituminous and subbituminous coal mercury input) beginning mid 2009. Alternatively, the output based limit of 0.008 lb/GWhr if applied to all units would be about 11,136 ounces for the existing units that will be covered by this rule. For most units, especially those firing subbituminous coal, the output based limit is more stringent. The 90% control level of 16,693 ounces or less for existing units is compared to CAMR allocations of 51,008 ounces (1.594 tons) from 2010 to 2017 and 20,128 ounces (0.628 tons) beginning in 2018. Without the proposed rule, in order to comply with CAMR it will be necessary for Illinois plants to reduce emissions (or buy allowances) by over 70% in the period from 2010-2017 and over 88% beginning 2018. The cost of the proposed rule over that of CAMR would therefore be the incremental cost of complying with one rather than the other.

***Estimating Costs:*** Costs of control considered in this analysis are the following:

- Capital cost of the equipment being installed.
- The cost of any sorbent being injected
- Other operating and maintenance costs
- Costs associated with any impact to fly ash

For a simple sorbent injection (SI) system, capital costs are in the range of about $2/kw to $3/kw. We assume $2.5/kw in this analysis. For a TOXECON system, the capital costs are significantly higher and will vary somewhat based upon the difficulty associated with retrofitting a particular plant. For this analysis it will be assumed that TOXECON costs $60/kw, but recognizing that the costs for the plants that may implement TOXECON may differ substantially from this.

Direct operating and maintenance (O&M) costs include sorbent consumption as well as energy used, maintenance, and other replaceable items (i.e., filter bags for TOXECON systems). For a simple SI system, sorbent dominates the O&M costs and other O&M costs can mostly be neglected because they are relatively small. In the case of a TOXECON system, there are parasitic load impacts, filter bag replacements, and maintenance that increase costs.

With regard to the costs associated with impact to fly ash, in the cost analysis it was assumed that all fly ash revenues were lost for those plants that reported fly ash revenues in their 2004 EIA Form 767 and were projected to use activated carbon injection. For these units it was assumed that fly ash disposal costs increased as well. Table 8.8 shows reported 2004 Form 767 data and calculated $/ton values for disposal expense and sales revenue for Illinois units affected by this rule.

Sorbent injection has the potential to reduce fly ash sales revenues and increase fly ash disposal costs. From the data in Table 8.8, it was determined that $25/ton would be used for this combined effect for affected plants. In most cases this $25/ton differential exceeds the actual cost differential in Table 8.8. Moreover, this amount is likely to overestimate the impact because fly ash may be marketable for other less valuable purposes and because technologies for addressing fly ash with carbon are likely to be used to eliminate the need to dispose of fly ash with carbon in it. As a result, the ash disposal costs estimated in this analysis should be regarded as worst case.

To estimate the cost of complying with the proposal, it was assumed that each unit will attempt to achieve 90% mercury reduction or more. It is assumed that nearly all units install controls, although some are assumed to have adequate control from optimization of cobenefit controls. The installation of SI or TOXECON on all units that are not expected to achieve 90% through cobenefits is reasonable since it is likely that nearly all units – and all units of any significant size – will want to achieve close to 90% control or better in order to comply with the rule. This will most likely result in more mercury removal than needed because 30-day tests with sorbent injection have shown that about 93% removal is achieved with injection rates of about 3 lb/MMacf. However, the additional 3% "safety factor" over 90% removal is something the power plant owners will not likely take for granted – at least initially.

The units that are assumed to have adequate cobenefit controls with no additional controls needed are:

- Ameren's Dallman and Duck Creek units, and both of SIPCO's Marion units. These units fire bituminous coal and either have SCR and wet FGD or are CFB boilers with a fabric filter, which have been shown to result in 90% or near 90% removal. It is possible that these units may choose to install SI simply as a precaution. But, it is not envisioned that the SI will be used much, if at all. Since most of the cost of SI is the sorbent rather than the cost of the equipment it is reasonable to disregard as negligible possible installation costs.

All other units are assumed to require sorbent injection. Since Dynergy's Havana and Vermillion units are currently under consent decree to install a fabric filter, the costs of the fabric filter are not attributed to the proposed Illinois mercury rule, but the sorbent costs and any disposal costs are attributed to the proposed rule. Midwest Generation's Waukegan #7 and Will County #3 units are assumed to install a fabric filter/TOXECON since they have hot-side ESPs. The cost of the TOXECON retrofit is assumed to be $60/KW for these two units. All other units are assumed to install sorbent injection at about $2.50/KW. Of course, the sorbent injection systems will fall in at a range of costs from possibly under $2/KW to maybe $3/KW or more. Although there could be a factor of 2 difference from the high end to the low end of the range, when costs are evaluated on an annualized basis, a factor of two difference in the capital costs for the SI equipment is fairly negligible since the most significant cost is that of the sorbent.

According to information submitted to Illinois EPA by Dynegy, its Baldwin plant is already achieving 80% mercury removal. Since Dynegy must install fabric filters and FGD on three units, mercury removal is likely to improve. At worst, a sorbent injection system to achieve 50% removal of mercury (removes half of the remaining 20% to achieve a total 90% removal) could be installed with a sorbent injection rate below 1 lb/MMacf. Also, once the fabric filters are installed, the impact to fly ash sales will be mitigated by use of a TOXECON system. To accomplish this, it will be necessary to move the sorbent injection point from upstream of the CS-ESP to upstream of the fabric filter.

It is recognized that for some units that are small, owners may decide that it is not initially beneficial to install sorbent injection on these units to comply with the 2009 deadline. Therefore, some of these costs may be deferred from 2009 compliance to 2012. However, this should not make a large difference in the overall cost due to the small size of the units.

The estimated costs for compliance are shown in Table 8.7. Costs are shown for:

- All units achieving 90% with current technology
- All units achieving 90% except for Midwest Generation's Waukegan #7 and Will County 3, which install halogenated sorbent injection in lieu of TOXECON to achieve 50% removal
- Compliance with 2010 CAMR budget levels through control technology

The assumed control strategies for CAMR represent assumed approaches that minimize the annualized cost while achieving reduction under the CAMR budget. Actual power plant behavior may differ based on individual preferences. However, it is unlikely that a substantially higher or lower cost would result.

Levelized Constant 2006 Dollar Annual Capital cost is estimated by multiplying the total capital cost by an assumed Capital Recovery Factor of 14%. Costs per pound of mercury removed for compliance with the IL rule are around $8,100/lb of mercury captured. Estimated for the cost to comply with the 2010 CAMR state budget through use of control technology are also shown in Table 8.7, and the cost is lower at around $5,800/lb of mercury removal. Detailed unit costs are shown in Tables 8.9, and 8.10. *It is important to note that these estimates assume very conservatively high (worst-case) fly-ash disposal costs, which due to improved technology or alternative marketable uses for the fly ash, will likely drop substantially.*

**Table 8.7 Estimated Cost for IL Utilities of Complying with IL Mercury Rule and with 2010 CAMR**

| Cost | Units | IL Rule | 2010 CAMR |
|---|---|---|---|
| **Capital Cost** | $1000 | $75,593 | $35,515 |
| **Annualized Capital Cost (14% CRF)** | $1000 | $10,583 | $4,972 |
| **Annual Sorbent Cost** | $1000 | $41,729 | $18,665 |
| **Annual Ash Disposal Cost** | $1000 | $13,403 | $9,900 |
| **Annualized TOXECON O&M (excluding sorbent)** | $1000 | $425 | $0 |
| **Total Annual Cost** | $1000 | $66,140 | $33,537 |
| **Ounces Hg removed *** | 1000 ounces | 130* | 93* |
| **Cost per oz Hg removed *** | $/ounce | $507 | $361 |
| **Cost per lb Hg removed *** | $/lb | $8,118 | $5,783 |
| NOTE: columns may not add due to rounding<br>*No credit is taking for Hg reductions from cobenefits (-25,000 oz) because these would happen regardless of IL rule or CAMR | | | |

In Table 8.7 the estimated costs for meeting the proposed rule are compared with the estimated costs for complying with CAMR through installation of control technology. However, under CAMR power plants in Illinois may purchase allowances from power plants out of state that may have surplus allowances. These allowances will have a cost reflecting at least the cost of implementing control technology. Even if a company currently has allowances in excess of their needs, they will have value to the company because they can be banked and used to defer installation of control technology to a future date when it presumably will be more expensive to control mercury.

Allowance price predictions are uncertain and vary over a wide range. In any event, it is reasonable to say that the cost of allowances should be somewhat higher than the cost in the market for producing the allowances. Based upon estimates by the US DOE shown in Figure 8.19, the cost to produce allowances may be as low as $4,000-$6,000 per pound (not including impacts on fly ash disposal/sales). So, this may be a reasonable estimate to use for a lowest estimate of cost.

However, some expect allowance prices to cost much more than what DOE predicts as the price to produce them. According to Platts Power website 10/6/05,

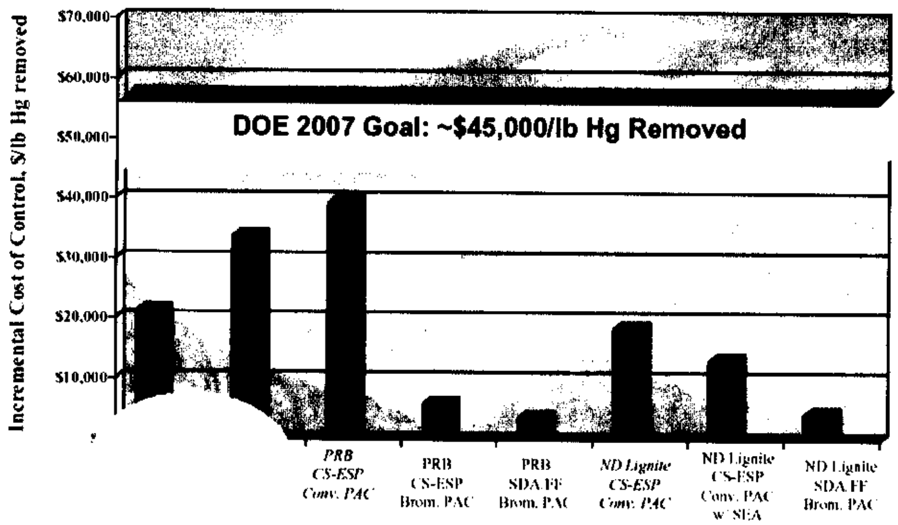
> *On mercury, the ICF study points out that cost of mercury reduction under EPA's program is between 20 cents/MWh and 40 cents/MWh. EPA has projected mercury allowances under its trading program to cost roughly $40,000/lb.*
> (http://www.platts.com/Magazines/POWER/Power%20News/2005/100605_5.xml)

It should be kept in mind that ICF's estimates for U.S. EPA did not incorporate the most recent technology developments – particularly halogenated sorbents. Thus, those estimates of control cost are likely high. Nevertheless, allowances could sell for far more than their cost to produce.

If an average CAMR mercury allowance price is assumed to be $5,000/lb (near the low end of the estimated cost to produce), then the annual expenditure on allowances by IL power plants will be roughly $29 million per year – only slightly lower than what is estimated in Table 8.7 as the cost to comply with CAMR through implementation of control technology. If, on the other hand, an average CAMR mercury allowance price is assumed to be $40,000/lb (EPA's recent estimate), then the annual expenditure on allowances by IL utilities will be roughly $232 million per year – many times what is estimated in Table 8.7 as the cost to comply with CAMR through implementation of control technology. So, relying on the currently non-existent CAMR allowance market is very risky for IL power plants, potentially resulting in far higher compliance cost than implementation of controls per Table 8.7.

This raises the practical matter of risk management. Since the capital costs of sorbent injection are fairly low and the risks of relying on the CAMR mercury allowance market are very high, it is reasonable to expect that most utilities in IL that do not have high co-benefit removal (most of the PRB units) will install sorbent injection equipment in advance of the CAMR date, regardless of the IL Rule. Therefore, the power plants in IL will incur much of the estimated capital expenditures associated with the IL Rule in any event.

**Figure 8.19 Incremental Cost of 70% Mercury Control** ***(Feeley, US DOE at PADEP Mercury Stakeholder Meeting, November 18, 2005)***




Based upon this analysis, we can use the values in Table 8.7 as reasonable estimates of the cost of compliance with the IL rule and with CAMR. With these numbers, it is estimated that the annualized ***additional*** cost of compliance with the IL mercury rule over the CAMR is roughly $32 million per year during the period of 2010 to 2017 (roughly $66 million/yr minus roughly $34 million/yr). Most of this cost is associated with additional sorbent usage. If the $29 million *minimum* estimated cost to comply with CAMR through purchase of allowances is used, then this incremental cost between the cost of the IL rule and 2010 CAMR is as high as $37 million. But, for the reasons cited earlier, the difference is very likely to be less than this.

Because the 2018 CAMR limit is roughly equal to the requirements for compliance with the proposed rule, the incremental cost will be negligible for 2018 compliance. In fact, the CAMR requirements could be somewhat more stringent than the 90% reduction target for IL at some point in the near future due to potential or planned growth in generation.

Tables 8.9 and 8.10 show details of calculations to estimate the cost to comply with the IL mercury rule and the cost to comply with 2010 CAMR. These are just examples of technology

| Table 8.8. 2004 Form 767 Reported Fly Ash and Calculated per ton Revenue and Disposal Expense | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Company | NAME | CITY | Fly Ash (1000 tons) | | | | | | Disposal Expense | | Revenue | |
| | | | Total | Landfill | Ponds | Onsite | Sold | Offsite | $1000 | $/ton * | $1000 | $/ton * |
| Ameren | Coffeen | St Louis | 11.9 | | | | | 11.9 | EN ** | | | |
| Ameren | Hutsonville | St Louis | 22.8 | | 22.8 | | | | EN ** | | | |
| Ameren | Meredosia | St Louis | 34.6 | | 34.6 | | | | EN ** | | | |
| Ameren | Newton | St Louis | 151.5 | 7.4 | 42.1 | | 102 | | EN ** | | $934 | $9.16 |
| Ameren | Duck Crk | St Louis | 62.4 | | 62.4 | | | | EN ** | | | |
| Ameren | Edwards | St Louis | 179.5 | | | 179.5 | | | EN ** | | | |
| Dominion | Kincaid | Kincaid | 96.3 | | | | | 96.3 | $728 | $7.56 | | |
| Dynegy | Baldwin | Decatur | 203 | | 102 | | 101 | | | $0.00 | $11 | $0.11 |
| Dynegy | Havana | Decatur | 92 | | 69 | | 23 | | | $0.00 | | $0.00 |
| Dynegy | Hennepin | Decatur | 44 | | 19 | | 25 | | | $0.00 | $191 | $7.64 |
| Dynegy | Vermilion | Decatur | 34 | 12 | 8 | | 14 | | $127 | $6.35 | $45 | $3.21 |
| Dynegy | Wood Rvr | Decatur | 59 | | 11 | | 48 | | | $0.00 | | $0.00 |
| EEI | Joppa | Joppa | 174.3 | | | | 174.3 | | | | $174 | $1.00 |
| Midwest | Collins | Chicago | 0 | | | | | | | | | |
| Midwest | Crawford | Chicago | 58.4 | | | | 32.7 | 25.7 | $598 | $23.27 | $141 | $4.31 |
| Midwest | Fisk | Chicago | 31.8 | | | | 16.6 | 15.2 | $359 | $23.62 | $78 | $4.70 |
| Midwest | Joliet 29 | Chicago | 114 | | | | 105 | 9 | $189 | $21.00 | $489 | $4.66 |
| Midwest | Joliet 9 | Chicago | 20.6 | | | | | 20.6 | $438 | $21.25 | | |
| Midwest | Powerton | Chicago | 120 | | | | | 120 | | $0.00 | | |
| Midwest | Waukegan | Chicago | 70.6 | | | | 42.7 | 27.9 | $640 | $22.94 | $205 | $4.80 |
| Midwest | Will Cnty | Chicago | 98.8 | | | | 9.4 | 89.4 | $1,898 | $21.23 | $51 | $5.43 |
| SILCO | Marion | Marion | 42.3 | | | | | 42.3 | $328 | $7.75 | | |
| CWLP | Dallman | Springfield | 53.9 | | 31.6 | | 22.3 | | $117 | $3.70 | | $0.00 |
| Total * | | | 1775.7 | 19.4 | 402.5 | 179.5 | 716.0 | 458.30 | $5,422 | | $2,319 | |
| Percent of Total Fly Ash * | | | 100% | 1% | 23% | 10% | 40% | 26% | | | | |

*All values as reported in EIA Form 767 except as denoted by asterisk (*)*

*** Ameren did not report Disposal Expense*

## Table 8.9 Example Technology Selection and Cost for IL Mercury Rule Compliance

| Owner | Plant Name | Capacity MW | Technology | Capital Cost, $1000 | Sorbent Cost $1000/yr | TOXECON O&M, $1000 | Ash disposal, $1000 | Annual Coal Use (1000 tons) | Hg reduced | Hg Output |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Ameren | DUCK CREEK | 441 | Cobenefit | $0 | $0 | $0 | $0 | 989 | 2,278 | 253 |
| Ameren | NEWTON | 617 | SI | $1,543 | $1,833 | $0 | $2,550 | 2,220 | 6,608 | 497 |
| Ameren | NEWTON | 617 | SI | $1,543 | $1,893 | $0 | $0 | 2,172 | 6,463 | 486 |
| Ameren | E D EDWARDS | 136 | SI | $340 | $331 | $0 | $0 | 449 | 1,338 | 101 |
| Ameren | E D EDWARDS | 281 | SI | $703 | $711 | $0 | $0 | 909 | 2,705 | 204 |
| Ameren | E D EDWARDS | 361 | SI | $903 | $1,055 | $0 | $0 | 1,211 | 3,603 | 271 |
| Ameren | COFFEEN | 389 | SI | $973 | $2,288 | $0 | $0 | 968 | 2,306 | 174 |
| Ameren | COFFEEN | 617 | SI | $1,543 | $4,032 | $0 | $0 | 1,702 | 4,052 | 305 |
| Ameren | HUTSONVILLE | 76 | SI | $190 | $284 | $0 | $0 | 130 | 310 | 23 |
| Ameren | HUTSONVILLE | 77 | SI | $193 | $359 | $0 | $0 | 165 | 392 | 30 |
| Ameren | MEREDOSIA | 31 | SI | $78 | $15 | $0 | $0 | 20 | 60 | 5 |
| Ameren | MEREDOSIA | 31 | SI | $78 | $15 | $0 | $0 | 19 | 57 | 4 |
| Ameren | MEREDOSIA | 31 | SI | $78 | $30 | $0 | $0 | 36 | 107 | 8 |
| Ameren | MEREDOSIA | 31 | SI | $78 | $30 | $0 | $0 | 38 | 113 | 9 |
| Ameren | MEREDOSIA | 239 | SI | $598 | $605 | $0 | $0 | 721 | 2,147 | 162 |
| CWLP | DALLMAN | 87.5 | Cobenefit | $0 | $0 | $0 | $0 | 281 | 646 | 72 |
| CWLP | DALLMAN | 86 | Cobenefit | $0 | $0 | $0 | $0 | 274 | 631 | 70 |
| CWLP | DALLMAN | 207 | Cobenefit | $0 | $0 | $0 | $0 | 600 | 1,383 | 154 |
| Dynegy | BALDWIN | 623 | SI | $1,558 | $439 | $0 | $0 | 2,324 | 6,917 | 521 |
| Dynegy | BALDWIN | 635 | SI | $1,588 | $455 | $0 | $0 | 2,253 | 6,704 | 505 |
| Dynegy | BALDWIN | 635 | SI | $1,588 | $505 | $0 | $0 | 2,504 | 7,451 | 561 |
| Dynegy | HAVANA | 488 | SI | $1,220 | $511 | $0 | $0 | 1,190 | 3,542 | 267 |
| Dynegy | HENNEPIN | 74 | SI | $185 | $216 | $0 | $625 | 276 | 822 | 62 |
| Dynegy | HENNEPIN | 231 | SI | $578 | $709 | $0 | $0 | 874 | 2,601 | 196 |
| Dynegy | VERMILION | 74 | SI | $185 | $112 | $0 | $0 | 206 | 490 | 37 |
| Dynegy | VERMILION | 109 | SI | $273 | $178 | $0 | $0 | 311 | 740 | 56 |
| Dynegy | WOOD RIVER | 113 | SI | $283 | $275 | $0 | $1,200 | 351 | 1,044 | 79 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Dynegy | WOOD RIVER | 372 | SI | $930 | $942 | $0 | $0 | 1,048 | 3,117 | 235 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $713 | $0 | $0 | 819 | 2,439 | 184 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $713 | $0 | $0 | 814 | 2,423 | 182 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $713 | $0 | $0 | 822 | 2,445 | 184 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $731 | $0 | $0 | 842 | 2,505 | 189 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $757 | $0 | $4,350 | 875 | 2,603 | 196 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $757 | $0 | $0 | 869 | 2,586 | 195 |
| Kincaid | KINCAID | 660 | SI | $1,650 | $1,607 | $0 | $0 | 1,824 | 5,427 | 408 |
| Kincaid | KINCAID | 660 | SI | $1,650 | $1,928 | $0 | $0 | 2,122 | 6,314 | 475 |
| Marion | MARION | 170 | cobenefit | $0 | $0 | $0 | $0 | 642 | 1,478 | 164 |
| Marion | MARION | 120 | cobenefit | $0 | $0 | $0 | $0 | 422 | 973 | 108 |
| Midwest | JOLIET 29 | 330 | SI | $825 | $643 | $0 | $0 | 766 | 2,280 | 172 |
| Midwest | JOLIET 29 | 330 | SI | $825 | $787 | $0 | $0 | 939 | 2,793 | 210 |
| Midwest | JOLIET 29 | 330 | SI | $825 | $803 | $0 | $0 | 958 | 2,850 | 215 |
| Midwest | JOLIET 29 | 330 | SI | $825 | $803 | $0 | $0 | 958 | 2,850 | 215 |
| Midwest | JOLIET 9 | 360 | SI | $900 | $1,402 | $0 | $2,625 | 1,420 | 4,225 | 318 |
| Midwest | CRAWFORD | 239 | SI | $598 | $594 | $0 | $825 | 755 | 2,248 | 169 |
| Midwest | CRAWFORD | 358 | SI | $895 | $906 | $0 | $0 | 1,119 | 3,331 | 251 |
| Midwest | POWERTON | 446.5 | SI | $1,116 | $1,304 | $0 | $0 | 1,520 | 4,522 | 340 |
| Midwest | POWERTON | 446.5 | SI | $1,116 | $1,217 | $0 | $0 | 1,418 | 4,221 | 318 |
| Midwest | POWERTON | 446.5 | SI | $1,116 | $1,217 | $0 | $0 | 1,418 | 4,221 | 318 |
| Midwest | POWERTON | 446.5 | SI | $1,116 | $1,196 | $0 | $0 | 1,393 | 4,145 | 312 |
| Midwest | WAUKEGAN | 121 | SI | $303 | $354 | $0 | $636 | 446 | 1,327 | 100 |
| Midwest | WAUKEGAN | 328 | TOXECON | $19,680 | $479 | $241 | $0 | 1,106 | 3,185 | 354 |
| Midwest | WAUKEGAN | 355 | SI | $888 | $1,072 | $0 | $0 | 1,217 | 3,621 | 273 |
| Midwest | WILL COUNTY | 188 | SI | $470 | $229 | $0 | $191 | 286 | 851 | 64 |
| Midwest | WILL COUNTY | 184 | SI | $460 | $269 | $0 | $0 | 343 | 1,021 | 77 |
| Midwest | WILL COUNTY | 299 | TOXECON | $17,940 | $364 | $183 | $0 | 858 | 2,472 | 275 |
| Midwest | WILL COUNTY | 598 | SI | $1,495 | $1,456 | $0 | $0 | 1,653 | 4,921 | 370 |
| Midwest | FISK | 374 | SI | $935 | $892 | $0 | $400 | 996 | 2,964 | 223 |
| **Total** | | | | $75,593 | $41,729 | $425 | $13,403 | 53,859 | 155,869 | 12,200 |

**Table 8.10 Example Technology Selection and Cost for Compliance with 2010 CAMR**

| Owner | Plant Name | Capacity MW | Technology | Capital Cost, $1000 | Sorbent Cost $1000/yr | TOXECON O&M, $1000 | Ash disposal, $1000 | Annual Coal Use (1000 tons) | Hg reduced | Hg Output |
|---|---|---|---|---|---|---|---|---|---|---|
| Ameren | DUCK CREEK | 441 | cobenefit | $0 | $0 | $0 | $0 | 989 | 2,278 | 253 |
| Ameren | NEWTON | 617 | SI | $0 | $0 | $0 | $0 | 2,220 | 0 | 7,105 |
| Ameren | NEWTON | 617 | SI | $1,543 | $789 | $0 | $0 | 2,172 | 4,864 | 2,085 |
| Ameren | E D EDWARDS | 136 | SI | $340 | $138 | $0 | $0 | 449 | 1,007 | 432 |
| Ameren | E D EDWARDS | 281 | | $0 | $0 | $0 | $0 | 909 | 0 | 2,909 |
| Ameren | E D EDWARDS | 361 | | $0 | $0 | $0 | $0 | 843 | 0 | 2,159 |
| Ameren | COFFEEN | 389 | SI | $973 | $1,525 | $0 | $0 | 968 | 1,736 | 744 |
| Ameren | COFFEEN | 617 | SI | $1,543 | $2,688 | $0 | $0 | 1,702 | 3,050 | 1,307 |
| Ameren | HUTSONVILLE | 76 | SI | $190 | $62 | $0 | $0 | 187 | 418 | 179 |
| Ameren | HUTSONVILLE | 77 | SI | $193 | $78 | $0 | $0 | 236 | 530 | 227 |
| Ameren | MEREDOSIA | 31 | | $0 | $0 | $0 | $0 | 20 | 0 | 64 |
| Ameren | MEREDOSIA | 31 | | $0 | $0 | $0 | $0 | 13 | 0 | 34 |
| Ameren | MEREDOSIA | 31 | | $0 | $0 | $0 | $0 | 36 | 0 | 115 |
| Ameren | MEREDOSIA | 31 | | $0 | $0 | $0 | $0 | 38 | 0 | 122 |
| Ameren | MEREDOSIA | 239 | | $0 | $0 | $0 | $0 | 721 | 0 | 2,308 |
| CWLP | DALLMAN | 87.5 | cobenefit | $0 | $0 | $0 | $0 | 281 | 646 | 72 |
| CWLP | DALLMAN | 86 | cobenefit | $0 | $0 | $0 | $0 | 274 | 631 | 70 |
| CWLP | DALLMAN | 207 | cobenefit | $0 | $0 | $0 | $0 | 600 | 1,383 | 154 |
| Dynegy | BALDWIN | 623 | SI | $1,558 | $439 | $0 | $0 | 2,324 | 5,207 | 2,231 |
| Dynegy | BALDWIN | 635 | SI | $1,588 | $455 | $0 | $0 | 2,253 | 5,046 | 2,162 |
| Dynegy | BALDWIN | 635 | SI | $1,588 | $505 | $0 | $0 | 2,504 | 5,608 | 2,404 |
| Dynegy | HAVANA | 488 | SI | $1,220 | $511 | $0 | $0 | 1,190 | 3,428 | 381 |
| Dynegy | HENNEPIN | 74 | SI | $185 | $90 | $0 | $625 | 276 | 619 | 265 |
| Dynegy | HENNEPIN | 231 | SI | $578 | $295 | $0 | $0 | 874 | 1,958 | 839 |
| Dynegy | VERMILION | 74 | SI | $185 | $112 | $0 | $0 | 206 | 474 | 53 |
| Dynegy | VERMILION | 109 | SI | $273 | $178 | $0 | $0 | 311 | 716 | 80 |
| Dynegy | WOOD RIVER | 113 | SI | $283 | $115 | $0 | $1,200 | 351 | 786 | 337 |
| Dynegy | WOOD RIVER | 372 | SI | $930 | $392 | $0 | $0 | 1,048 | 2,346 | 1,006 |

| Owner | Plant Name | Capacity MW | Technology | Capital Cost, $1000 | Sorbent Cost $1000/yr | TOXECON O&M, $1000 | Ash disposal, $1000 | Annual Coal Use (1000 tons) | Hg reduced | Hg Output |
|---|---|---|---|---|---|---|---|---|---|---|
| Joppa | JOPPA STEAM | 183 | SI | $458 | $297 | $0 | $0 | 819 | 1,836 | 787 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $297 | $0 | $0 | 814 | 1,824 | 782 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $297 | $0 | $2,900 | 822 | 1,840 | 789 |
| Joppa | JOPPA STEAM | 183 | SI | $458 | $304 | $0 | $0 | 842 | 1,885 | 808 |
| Joppa | JOPPA STEAM | 183 | | $0 | $0 | $0 | $0 | 875 | 0 | 2,799 |
| Joppa | JOPPA STEAM | 183 | | $0 | $0 | $0 | $0 | 869 | 0 | 2,781 |
| Kincaid | KINCAID | 660 | SI | $1,650 | $670 | $0 | $0 | 1,824 | 4,085 | 1,751 |
| Kincaid | KINCAID | 660 | SI | $1,650 | $803 | $0 | $0 | 2,122 | 4,753 | 2,037 |
| Marion | MARION | 170 | cobenefit | $0 | $0 | $0 | $0 | 642 | 1,478 | 164 |
| Marion | MARION | 120 | cobenefit | $0 | $0 | $0 | $0 | 422 | 973 | 108 |
| Midwest | JOLIET 29 | 330 | SI | $825 | $268 | $0 | $0 | 766 | 2,206 | 245 |
| Midwest | JOLIET 29 | 330 | SI | $825 | $328 | $0 | $0 | 939 | 2,703 | 300 |
| Midwest | JOLIET 29 | 330 | SI | $825 | $335 | $0 | $0 | 958 | 2,758 | 306 |
| Midwest | JOLIET 29 | 330 | SI | $825 | $335 | $0 | $0 | 958 | 2,758 | 306 |
| Midwest | JOLIET 9 | 360 | SI | $900 | $584 | $0 | $2,625 | 1,420 | 4,089 | 454 |
| Midwest | CRAWFORD | 239 | SI | $598 | $247 | $0 | $825 | 755 | 2,175 | 242 |
| Midwest | CRAWFORD | 358 | SI | $895 | $378 | $0 | $0 | 1,119 | 3,223 | 358 |
| Midwest | POWERTON | 446.5 | SI | $1,116 | $544 | $0 | $0 | 1,520 | 4,376 | 486 |
| Midwest | POWERTON | 446.5 | SI | $1,116 | $507 | $0 | $0 | 1,418 | 4,085 | 454 |
| Midwest | POWERTON | 446.5 | SI | $1,116 | $507 | $0 | $0 | 1,418 | 4,085 | 454 |
| Midwest | POWERTON | 446.5 | SI | $1,116 | $498 | $0 | $0 | 1,393 | 4,012 | 446 |
| Midwest | WAUKEGAN | 121 | SI | $303 | $147 | $0 | $1,075 | 446 | 1,284 | 143 |
| Midwest | WAUKEGAN | 328 | | $0 | $0 | $0 | $0 | 1,106 | 0 | 3,539 |
| Midwest | WAUKEGAN | 355 | SI | $888 | $447 | $0 | $0 | 1,217 | 3,504 | 389 |
| Midwest | WILL COUNTY | 188 | SI | $470 | $95 | $0 | $250 | 286 | 824 | 92 |
| Midwest | WILL COUNTY | 184 | SI | $460 | $112 | $0 | $0 | 343 | 988 | 110 |
| Midwest | WILL COUNTY | 299 | | $0 | $0 | $0 | $0 | 858 | 0 | 2,747 |
| Midwest | WILL COUNTY | 598 | SI | $1,495 | $607 | $0 | $0 | 1,653 | 4,762 | 529 |
| Midwest | FISK | 374 | SI | $935 | $372 | $0 | $400 | 996 | 2,869 | 319 |
| Total | | | | $35,515 | $19,297 | $0 | $9,900 | 53,615 | 117,504 | 49,422 |

choices. Of course, the power plant would make its own decision about the best approach to compliance.

## 9.0 Economic Modeling

In addition to the detailed mercury control and cost analysis performed in Section 8 of this document, Illinois utilized the services of ICF Resources Incorporated (ICF) to evaluate the economic impact of the Illinois Mercury Rule using the Integrated Planning Model (IPM®). Developed by ICF and used to support public and private sector clients, IPM is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints. IPM can be used to evaluate the cost and emissions impacts of proposed policies to limit emissions of sulfur dioxide (SO2), nitrogen oxides (NOx), carbon dioxide (CO2), and mercury (Hg) from the electric power sector. The IPM was a key analytical tool in developing the Clean Air Interstate Rule (CAIR) and the President's Clear Skies Initiative.

Specifically, ICF conducted a study utilizing IPM to analyze the cost impacts of the proposed rule, referenced to the "Illinois Mercury Rule". This study focused on the impacts of the mercury rule in terms of costs to the power sector and costs to electricity consumers. National level and state level results were determined and presented. In addition, the study highlighted the effects on generation, coal consumption, control equipment, and emissions.

Of note is that Illinois updated several of the assumptions and inputs used in previous IPM runs involving Illinois EGUs, including:

- Costs of mercury controls, in particular the costs of halogenated PAC
- Coal type utilized by Illinois EGUs
- Existing control configurations at Illinois EGUs
- Estimated mercury emissions from Illinois EGUs

In paritucular, for modeling the proposed mercury rule, Illinois modified the IPM mercury control assumptions to include mercury control using halogenated PAC. The mercury control assumptions used for IPM modeling performed for U. S. EPA had been based on data developed several years ago using untreated activated carbon as the basic mercury control technology. Therefore, ICF modified these control technology assumptions to be consistent with current understanding of control technologies and costs.

## 9.1 Scenarios Examined

ICF examined three cases (or scenarios) using IPM:

(i) A Base Case with no additional Federal air regulations in place beyond existing regulations, including the Title IV $SO_2$ program, the $NO_x$ SIP Call requirements, and other state regulations in place (the Base Case);

(ii) A case based upon the run above, but also including the final CAIR and CAMR as put forth by U.S. EPA (the CAIR/CAMR case);

(iii) A case with the CAIR in place, the CAMR in place for all states but Illinois, and the proposed Illinois Mercury Rule for affected sources in Illinois, referred to the Policy Case.

The difference between the Base Case and either of the two regulatory scenarios represents the impact of that regulation. In this study, differences between the second and first case represent the costs of the CAIR/CAMR rule, based on the assumptions underlying this study. The differences between the third and the first case represent the costs of the proposed rule, based again on the underlying assumptions. A comparison of these two cost impact estimates reflects the incremental cost of the proposed rule over the

CAIR/CAMR case. The report focused on this difference (i.e., difference between scenarios iii vs. ii).

ICF was not able to model the exact features of the proposed rule. Based on discussions with Illinois, and given the available time for this analysis, ICF structured the analysis as follows:

- First, ICF assumed that compliance with Phase I of the rule is required at the beginning of 2009, although actual compliance is not required until July 1, 2009;

- Second, rather than model unit level emission rate limits for existing units, ICF simulated unit level emission rate limits based on unit level emissions caps calculated by Illinois EPA. For subbituminous units, the unit level cap was based on a 90 reduction in emissions from historic levels (after accounting for increased use of subbituminous coal). For bituminous plants, the cap reflects the rate limit and a fixed generation level. IPM model plant level emissions caps are the sum of the individual unit caps. Note that using caps to simulate a rate limit is a more restrictive policy. Under a rate limit policy, a unit would be able to increase generation and emissions so long as it remained under the rate. Under a cap, emissions do not increase over time.

- The rate limits (i.e., 0.020 or 0.0080 lbs Hg/GWh) were implemented for all potential coal and potential IGCC units in IPM's Mid-America Interconnected Network-04 (MANO) region (Illinois capacity consists of 88 percent of region's capacity).

- In addition to the plant level caps implemented across the two phases, a system level emissions limit was imposed that reflected the 90 percent reduction requirements of Phase I. This was calculated based on the 0.0080 lbs Hg/GWh emission rate limit. This system cap was applied to all Illinois affected units, which, in comparison, is a less restrictive requirement than the proposed rule.

IPM is a capacity planning and dispatch model that simulates the operation of the electric power system based upon engineering and economic fundamentals. It is supported by a detailed set of data and assumptions that characterize the current generation and transmission system; fuel markets; demand; environmental requirements; and system constraints. Additional inputs include new technology costs (including pollution control equipment), current environmental laws and regulations, and any potential future policies being modeled.

## 9.2 Results

This section provides ICF's basic summary of the results of the analysis focusing on the incremental impacts of the proposed rule, as represented by the differences between cases (iii) the proposed Mercury Rule, and (ii) the CAIR/CAMR rules.

Table 9.1 shows the changes in emissions for mercury, $SO_2$ and $NO_X$ for Illinois and at the national level. Due to the more stringent nature of the proposed mercury rule in Illinois relative to Illinois' allocations under CAMR, emissions of mercury in Illinois are lower by 4,754 lbs in 2009. This is an 85 percent reduction in Illinois mercury emissions relative to the Base and CAIR/CAMR cases.

Emission levels decrease in Illinois over time under the Policy Case reflecting increased stringency of the emissions constraints and reduced flexibility in compliance. Emissions in Illinois from all units total 883 lbs in 2009, falling to 789 lbs in 2015. This represents a reduction of 4,726 pounds and 1,674 pounds in 2009 and 2015, respectively. (Note that under the CAIR/CAMR case, Illinois would be a net purchaser of mercury emission allowances in 2018 given that its state budget under CAMR is 1,258 pounds of mercury.)

The $SO_2$ and $NO_x$ emissions in Illinois are also lower under the Policy Case relative to the CAIR/CAMR case. This results from reductions in coal-fired generation and an increase in scrubber installations in 2009 as a result of the proposed rule. The mercury emissions are also lower nation-wide, reflecting the reductions from Illinois units.

**Table 9.1**
**Emissions (thousand Tons or Lbs)**

| | (iii) Policy Case with IL Rule | | | (ii) Base Case with CAIR/CAMR | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Pollutant** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** |
| **IL State** | | | | | | | | | |
| Hg [1] | 883 | 789 | 799 | 5,609 | 2,463 | 1,926 | (4,726) | (1,674) | (1,127) |
| $SO_2$ (Title IV) | 232 | 212 | 206 | 309 | 268 | 266 | (77) | (56) | (60) |
| NOx (SIP Call) | 63 | 62 | 61 | 67 | 68 | 68 | (4) | (6) | (7) |
| **National** | | | | | | | | | |
| Hg [1] | 81,822 | 59,828 | 56,676 | 86,201 | 61,552 | 57,914 | (4,379) | (1,724) | (1,238) |
| $SO_2$ (Title IV) | 6,725 | 5,204 | 4,795 | 6,765 | 5,195 | 4,815 | (40) | 9 | (20) |
| NOx (SIP Call) | 2,514 | 2,366 | 2,272 | 2,516 | 2,365 | 2,268 | (2) | 1 | 4 |

1. Mercury emissions are reported in pounds; all other pollutants are reported in short tons.

Table 9.2 shows the changes in generation in Illinois and nationally from the Policy Case. The total generation in Illinois is lower by 2 percent in 2009 relative to the CAIR/CAMR case. By 2015 and 2018, total generation under the Policy Case has decreased by 7 and 5 percent, respectively, relative to the CAIR/CAMR case.

This reduction is driven by reductions in coal-fired generation in Illinois. Illinois is a net exporter of energy – that is, it generates more than is required to meet its internal demand. Under the CAIR/CAMR case, Illinois coal fired generation would be reduced somewhat – by 2 percent in 2009, and 6 percent in 2018. However, under the Policy Case, the impact is more pronounced with reductions in coal-fired generation in 2009, 2015, and 2018 of 4 percent, 15 percent, and 10 percent, respectively, relative to the CAIR/CAMR case. With more stringent regulations in place in Illinois, the Illinois coal plants are somewhat less competitive, and thus, have fewer opportunities to export coal-fired generation.

The projected decrease in coal generation is slightly compensated by an increase in generation for oil and natural gas-fired units in Illinois. However, the bulk of the displaced Illinois generation is made up in the rest of MANO and in neighboring regions. Illinois remains a net exporter, but to a lesser degree. Thus, decreases in generation from Illinois units result in a net decline in exports of energy from the MANO region. Total generation decreases overall at the national level, reflecting marginal changes in losses, pumped storage activity and transmission.

**Table 9.2**
**Generation (GWh)**

| | (iii) Policy Case with IL Rule | | | (ii) Base Case with CAIR/CAMR | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Generation** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** |
| | | | | **IL State** | | | | | |
| Coal | 102,514 | 93,733 | 98,375 | 107,327 | 109,692 | 109,523 | (4,813) | (15,958) | (11,148) |
| Hydro | 92 | 92 | 92 | 92 | 92 | 92 | - | - | - |
| Nuclear | 95,092 | 95,259 | 96,575 | 95,092 | 95,259 | 96,575 | - | - | - |
| Oil/Natural Gas | 3,693 | 7,528 | 8,648 | 3,367 | 5,815 | 7,908 | 326 | 1,713 | 739 |
| Other | 166 | 166 | 166 | 166 | 166 | 166 | - | - | - |
| Renewables | 589 | 1,097 | 1,097 | 589 | 1,097 | 1,097 | - | - | - |
| Grand Total | 202,146 | 197,875 | 204,953 | 206,633 | 212,120 | 215,361 | (4,487) | (14,245) | (10,408) |
| | | | | **National** | | | | | |
| Coal | 2,187,043 | 2,448,517 | 2,650,066 | 2,189,406 | 2,448,364 | 2,640,484 | (2,362) | 153 | 9,582 |
| Hydro | 287,113 | 290,063 | 288,249 | 287,218 | 290,205 | 289,165 | (104) | (142) | (916) |
| Nuclear | 796,715 | 810,065 | 807,698 | 796,715 | 810,065 | 807,698 | - | - | - |
| Oil/Natural Gas | 889,675 | 1,023,427 | 1,063,795 | 887,468 | 1,023,775 | 1,073,736 | 2,207 | (348) | (9,940) |
| Other | 44,066 | 51,731 | 49,497 | 44,066 | 51,731 | 49,497 | - | - | - |
| Renewables | 81,947 | 101,232 | 108,330 | 81,947 | 101,178 | 108,361 | - | 54 | (31) |
| Grand Total | 4,286,560 | 4,725,036 | 4,967,636 | 4,286,820 | 4,725,318 | 4,968,941 | (260) | (283) | (1,305) |

Table 9.3 shows the impact on total production costs under the Policy Case, as compared to the CAIR/CAMR case. Production costs shown are the total going-forward costs for meeting electricity demand, including fuel costs, variable operating and maintenance costs, fixed operating and maintenance costs, and annualized capital costs (including costs for new capacity and retrofits). As shown in Table 9.3, the total costs at the national level are higher under the Policy Case by $147 to $267 million per year over the time frame analyzed. These are very small impacts relative to total national costs (about two-tenths of a percent).

Under the Policy Case, production costs in Illinois are higher in 2009, by about half the national level ($68 million). This reflects a mix of increased capital costs and variable operating and maintenance costs due to additional controls required, partially offset by displaced fuel consumption from lost generation.

In later years under Phase II of the proposed Illinois Mercury Rule, production costs are lower in all years (by $188 and $53 million, in 2015 and 2018, respectively). This reduction in costs reflects the lower level of generation that occurs in Illinois due to the proposed rule (which is down by between 5-7 percent in these years), offset by the increased cost of retrofit decisions. Capital costs are up in these years; however, these costs are offset by the reduced fuel costs and net decreases in variable operating and maintenance costs.

Note that these costs are production costs and do not reflect the opportunity costs (i.e., lost revenues and associated profits) of the lost exports. Generation in Illinois is sufficient to meet internal load and export power to neighboring regions (this assumes that Illinois generators share proportionally in the exports). Under the Illinois Mercury Rule, this remains true; however, the level of exports declines, with attendant loss of revenues from these sales. ICF did not quantify these lost revenues.

**Table 9.3**
**Total Production Costs (1999 million dollars) Impacts of the Illinois Mercury Rule**

| | (iii) Policy Case with IL Rule | | | | (ii) Base Case with CAIR/CAMR | | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plant Type** | **2009** | **2015** | **2018** | | **2009** | **2015** | **2018** | | **2009** | **2015** | **2018** |
| **IL State** | | | | | | | | | | | |
| Variable O&M | 357 | 340 | 355 | | 306 | 372 | 382 | | 51 | (32) | (27) |
| Fixed O&M | 2,030 | 2,137 | 2,316 | | 2,003 | 2,134 | 2,300 | | 28 | 3 | 16 |
| Fuel Total | 1,931 | 1,908 | 1,963 | | 1,995 | 2,069 | 2,102 | | (63) | (162) | (140) |
| Capital | 84 | 105 | 295 | | 32 | 101 | 198 | | 53 | 3 | 97 |
| Total Cost | 4,403 | 4,488 | 4,929 | | 4,335 | 4,676 | 4,982 | | 68 | (188) | (53) |
| **National** | | | | | | | | | | | |
| Variable O&M | 7835 | 9495 | 10549 | | 7780 | 9496 | 10511 | | 56 | (2) | 38 |
| Fixed O&M | 28926 | 31772 | 33432 | | 28910 | 31749 | 33388 | | 16 | 23 | 44 |
| Fuel Total | 61818 | 65527 | 68945 | | 61759 | 65480 | 69139 | | 59 | 47 | (194) |
| Capital | 2574 | 13256 | 19167 | | 2558 | 13057 | 18807 | | 16 | 199 | 360 |
| Total Cost | 101,153 | 120,049 | 132,094 | | 101007 | 119782 | 131846 | | 147 | 267 | 248 |

Table 9.4 shows the changes in total costs, generation, and average production costs in Illinois and nationally under the two policy cases. Despite lower overall production costs in Illinois (due to lower generation levels), average production costs increase under the Policy Case. They increase by $0.80 per MWh in 2009, $0.64 per MWh in 2015, and $0.92 per MWh in 2018. Thus, average production costs in Illinois increase by 4 percent, 3 percent, and 4 percent in 2009, 2015 and 2018, respectively under the Policy Case. The increase at the national level is minimal (less than two-tenths of a percent) in all years.

The decrease in total costs in Illinois is a result of the decrease in generation levels from Illinois units offset by the increased costs for compliance. In these years, these reductions outweigh the increase in production costs due to the mercury rule. Though the decrease in generation leads to a decrease in the exports of energy, the MANO region is still a net exporter of energy. However, the region must import capacity in order to meet summer peak reserve requirements.

**Table 9.4**
**Total Costs (Millions of $) and Average Production Costs (1999 $/MWh)**

| | (iii) Policy Case with IL Rule | | | (ii) Base Case with CAIR/CAMR | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Plant Type** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** |
| **IL State** | | | | | | | | | |
| Total Costs (MM$) | 4,403 | 4,488 | 4,929 | 4,335 | 4,676 | 4,982 | 68 | (188) | (53) |
| Total Generation (GWh) | 202,146 | 197,875 | 204,953 | 206,633 | 212,120 | 215,361 | (4,487) | (14,245) | (10,408) |
| Average Costs (mills/kWh) | 21.78 | 22.68 | 24.05 | 20.98 | 22.04 | 23.13 | 0.80 | 0.64 | 0.92 |
| **National** | | | | | | | | | |
| Total Costs (MM$) | 101,153 | 120,049 | 132,094 | 101,007 | 119,782 | 131,846 | 147 | 267 | 248 |
| Total Generation (GWh) | 4,286,560 | 4,725,036 | 4,967,636 | 4,286,820 | 4,725,318 | 4,968,941 | (260) | (283) | (1,305) |
| Average Costs (mills/kWh) | 23.60 | 25.41 | 26.59 | 23.56 | 25.35 | 26.53 | 0.04 | 0.06 | 0.06 |

Table 9.5 shows the changes in firm wholesale electricity prices between the two policy cases being compared. The firm price is made up of two components: marginal energy and marginal capacity prices. Firm prices in Illinois under the Policy Case increase by $0.50/MWh in 2009, by $1.46/MWh in 2015, and $1.00/MWh in 2018. Marginal energy prices reflect the production costs of the marginal plant – the last plant to be dispatched in each hour. The Policy Case results on an increase in production costs and increases the costs of the marginal unit, and thus increases the marginal energy prices over the CAIR/CAMR case. This in turn leads to higher firm prices for all the years. The rule has a negligible impact on firm electricity prices nation-wide -- $0.07-0.15/MWh across the study horizon.

**Table 9.5**
**Wholesale Firm Electricity Price (1999 $/MWh)**

| | (iii) Policy Case with IL Rule | | | | (ii) Base Case with CAIR/CAMR | | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **2009** | **2015** | **2018** | | **2009** | **2015** | **2018** | | **2009** | **2015** | **2018** |
| IL (MANO) | 27.40 | 41.08 | 50.29 | | 26.90 | 39.62 | 49.29 | | 0.50 | 1.46 | 1.00 |
| National | 37.73 | 39.33 | 45.45 | | 37.66 | 39.23 | 45.31 | | 0.07 | 0.10 | 0.14 |

** The firm wholesale price represents the sum of marginal energy costs and marginal capacity price, spread across all generation. The prices are energy weighted segmental prices.
** Wholesale marginal energy and capacity prices in IPM are forecast at the IPM model region level for each run-year, season, and segment. The wholesale prices for MANO are presented as representative of Illinois.

IPM is a wholesale power market model. As such, its outputs include estimates of increased generation system costs (and hence average cost increases) and impacts on marginal energy and capacity costs. It does not provide projections of retail rates or retail price impacts. Therefore, it is necessary to estimate retail rate impacts based on the available outputs of the model.

Final retail rates depend on the nature of the market in each state (deregulated or not) and the ratemaking process, including how costs increases are allocated among sectors, what returns are ultimately allowed, and other factors. In Illinois, an auction process was recently established that allows for the procurement of electricity at wholesale by Ameren and ComEd for delivery to Illinois retail consumers, requiring supply service from their local distribution utility beginning in 2007.

The estimate of retail rate impacts estimated here reflects an assumption that retail rates over the study horizon would increase by the increase in wholesale energy prices. Given the competitive nature of wholesale markets in Illinois, this is not an unreasonable assumption.

A number of other inputs and assumptions are required to calculate the retail rate impact. It is assumed that the increase is applied equally across all sectors – that is, all sectors bear the same incremental per kWh wholesale cost increases. Second, a forecast of baseline retail rates is required to which to add this increase. For this purpose, ICF obtained from the U.S. DOE's "Energy Information Agency's (EIA) Annual Energy Outlook (AEO) 2006", a forecast of retail electricity rates over the study horizon for the MAIN (Mid-America Interconnected Network) region. The underlying assumption is that forecast retail rates for MAIN are applicable to the State of Illinois. The AEO 2006 scenario from which this rate is taken is comparable to the CAIR/CAMR case in that those two rules are assumed to be in place in the AEO analysis. However, it is important to note that the two cases may differ on other aspects.

Table 9.6 shows the changes in retail electricity prices by sector. ICF calculated the retail electricity prices by applying the IPM projected increase in firm wholesale electricity prices resulting from the proposed Illinois rule to the retail rates obtained from AEO 2006 (adjusted to be consistent year dollars). The Policy Case would result in an increase in the production costs and thus energy prices. This, in turn, leads to higher retail prices for all sectors.

Price increases range from 0.05 cents per kWh to 0.15 cents per kWh over the study horizon. These represent increases of one to two percent in the residential and industrial sectors and one to 3.5 percent in the commercial sector. Under this methodology, increases in the commercial and industrial sectors are proportionately higher given the lower starting base rates.

**Table 9.6**
**Estimated Impacts on Retail Electricity Prices in Illinois**
(1999 cents per kWh)*

| | (iii) Policy Case with IL Rule | | | (ii) Base Case with CAIR/CAMR | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Region** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** |
| **IL State** | | | | | | | | | |
| Residential | 7.43 | 7.67 | 7.75 | 7.38 | 7.52 | 7.65 | 0.05 | 0.15 | 0.10 |
| Industrial | 6.50 | 6.50 | 6.65 | 6.44 | 6.35 | 6.55 | 0.05 | 0.15 | 0.10 |
| Commercial | 4.58 | 4.32 | 4.45 | 4.53 | 4.17 | 4.35 | 0.05 | 0.15 | 0.10 |

*Retail price are estimated by adding the incremental increase in Firm Wholesale Electricity Prices (shown in Table 1-5) between the cases to the retail prices by sector. Retail prices by sector were obtained from EIA's AEO 2006 data. Refer to Table 62: Electric Power Projections by EMM region". Data for the "MAIN" region was used to estimate prices for Illinois.

Tables 9.7 and 9.8 show the changes in total expenditures for each sector on an annual and monthly basis under the Policy Case. In 2009, residential customer expenditures increase by $28 million; industrial expenditures for electricity increase by $31 million while commercial expenditures increase by $27 million. In 2015, increased expenditures total $87, $101, and $83 million for the residential, commercial, and industrial sectors, respectively. On a monthly basis, the average household will pay $0.49, $1.50 and $1.06 more in 2009, 2015 and 2018, respectively, as a result of incremental impact of the proposed Illinois Mercury Rule. These numbers are the increase in monthly expenditures in the residential sector (in Table 9.8) divided by the number of households in Illinois. The number of households in Illinois was estimated based on forecasts of total population and an estimate of current persons per households, based on Census data.

**Table 9.7**
**Total Expenditures for Electricity by Sector (1999 million dollars)**

| | (iii) Policy Case with IL Rule | | | | (ii) Base Case with CAIR/CAMR | | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **2009** | **2015** | **2018** | | **2009** | **2015** | **2018** | | **2009** | **2015** | **2018** |
| | | | | | **IL State** | | | | | | |
| Residential | 4,109 | 4,569 | 4,786 | | 4,081 | 4,482 | 4,724 | | 28 | 87 | 62 |
| Industrial | 4,038 | 4,482 | 4,848 | | 4,007 | 4,382 | 4,775 | | 31 | 101 | 73 |
| Commercial | 2,488 | 2,449 | 2,570 | | 2,461 | 2,366 | 2,512 | | 27 | 83 | 58 |

Total bill payments for each sector are calculated as follows. First, an estimate of sales to each sector in Illinois is made based the AEO 2006 projections of each sector's share of total retail sales (for the MAIN region). For example, if AEO projects that in 2010 residential customers will account for x percent of total retail electricity sales, ICF assumed the same share. ICF estimates Illinois sales based on the assumption that Illinois sales as a proportion of total Illinois generation are the same as that of the MANO region. Finally, the retail prices estimated in Table 1-6 are multiplied by generation to derive total annual expenditures for electricity by sector.

**Table 9.8**
**Impacts on Monthly Expenditures for Electricity by Sector (1999 million dollars)**

| | (iii) Policy Case with IL Rule | | | | (ii) Base Case with CAIR/CAMR | | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **2009** | **2015** | **2018** | | **2009** | **2015** | **2018** | | **2009** | **2015** | **2018** |
| | | | | | **IL State** | | | | | | |
| Residential | 342 | 381 | 399 | | 340 | 374 | 394 | | 2 | 7 | 5 |
| Industrial | 336 | 374 | 404 | | 334 | 365 | 398 | | 3 | 8 | 6 |
| Commercial | 207 | 204 | 214 | | 205 | 197 | 209 | | 2 | 7 | 5 |

These costs are calculated by dividing the annual payments in 1-7 by 12.

Table 9.9 shows the changes in control technology retrofits between the two policy cases. The proposed Illinois Mercury Rule requires an additional 11 gigawatts (GW) of activated carbon injection (ACI) controls and 2 GW of flue gas desulfurization (FGD) controls by 2009. The incremental level of retrofits required by the proposed rule shrinks by 2018 as the difference between the stringency of the Illinois rule and CAMR rule shrinks. By 2018, the level of scrubber retrofits required is lower than that predicted under CAIR/CAMR, and the least-cost response to the proposed Illinois Mercury Rule is to add some scrubbers earlier. Similarly, for ACI, the least-cost response is to add about 8 GW of ACI earlier than would occur under CAIR/CAMR case. By 2018, the incremental level of ACI retrofits in Illinois is 2 GW. Note that incremental ACI retrofits occur in the rest of the nation (an additional 1.5 GW by 2015). This is due to the increased level of generation in the rest of the nation that makes up for lost exports from Illinois.

**Table 9.9**
**Control Technology Retrofits (Cumulative MW)**

| | (iii) Policy Case with IL Rule | | | (ii) Base Case with CAIR/CAMR | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Technology** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** | **2009** | **2015** | **2018** |
| **IL State** | | | | | | | | | |
| FGD | 2,556 | 2,762 | 2,762 | 387 | 2,836 | 2,836 | 2,168 | (74) | (74) |
| SCR | 1,748 | 1,826 | 1,826 | 1,799 | 2,121 | 2,121 | (51) | (295) | (295) |
| SNCR | - | - | - | - | - | - | - | - | - |
| ACI | 10,590 | 10,727 | 11,023 | - | 7,185 | 8,498 | 10,590 | 3,542 | 2,525 |
| **National** | | | | | | | | | |
| FGD | 38,578 | 72,100 | 85,019 | 36,948 | 73,530 | 85,543 | 1,630 | (1,431) | (525) |
| SCR | 34,362 | 51,042 | 64,747 | 34,223 | 51,213 | 65,181 | 139 | (171) | (434) |
| SNCR | 2,039 | 2,575 | 2,925 | 2,041 | 2,578 | 3,106 | (3) | (3) | (181) |
| ACI | 18,493 | 63,788 | 72,423 | 7,934 | 58,723 | 67,672 | 10,559 | 5,065 | 4,751 |

Table 9.10 summarizes the changes in coal consumption between the two cases. It also provides a full comparison of the Policy Case vs. the Base Case without CAIR/CAMR (second section of the table), and the CAIR /CAMR case vs. a case with neither rule in place (third section).

Under the CAIR/CAMR case, bituminous coal consumption falls by about 18 to 68 tons per trillion Btu (Tbtu) (or about 8 to 24 percent over the study horizon). Under the Policy Case, bituminous fuel consumption rises by 48 TBtu in 2009. It falls slightly in 2018 (18 TBtu or 10 percent) under the Policy Case, but by a much lesser amount than under the CAIR/CAMR case. Hence, relative to CAIR/CAMR case, the Policy Case leads to an increase in the use of bituminous coal and a decrease in the use of subbituminous coal in Illinois units. This reflects the incremental use of scrubbers in early years. These decreases in subbituminous coal consumption are substantially offset by increases in the rest of the nation. Coal prices are not affected by the proposed Illinois rule.

**Table 9.10**
**Coal Consumption (TBtu)**

| Comparison of Two Policy Cases | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (iii) Policy Case with IL Rule | | | | (ii) Base Case with CAIR/CAMR | | | | Delta (iii - ii) | |
| Coal Type | 2009 | 2015 | 2018 | 2009 | 2015 | 2018 | | 2009 | 2015 | 2018 |
| **IL State** | | | | | | | | | | |
| Bituminous | 268 | 254 | 262 | 201 | 214 | 212 | | 67 | 40 | 50 |
| Subbituminous | 808 | 728 | 751 | 924 | 942 | 942 | | (116) | (214) | (191) |
| Lignite | - | - | - | - | - | - | | - | - | - |
| Total | 1,077 | 982 | 1,013 | 1,126 | 1,156 | 1,154 | | (49) | (174) | (141) |
| **National** | | | | | | | | | | |
| Bituminous | 12,940 | 14,114 | 15,153 | 12,945 | 14,070 | 15,068 | | (5) | 44 | 86 |
| Subbituminous | 8,990 | 9,995 | 10,680 | 8,990 | 10,053 | 10,701 | | - | (58) | (21) |
| Lignite | 774 | 774 | 774 | 792 | 792 | 792 | | (18) | (18) | (18) |
| Total | 22,704 | 24,882 | 26,607 | 22,727 | 24,915 | 26,560 | | (23) | (32) | 47 |
| **Impact of the Illinois Rule** | | | | | | | | | | |
| | (iii) Policy Case with IL Rule | | | | (i) Base Case without CAIR/CAMR | | | | Delta (iii - i) | |
| **IL State** | | | | | | | | | | |
| Bituminous | 268 | 254 | 262 | 220 | 243 | 280 | | 48 | 11 | (18) |
| Subbituminous | 808 | 728 | 751 | 920 | 938 | 936 | | (112) | (211) | (185) |
| Lignite | - | - | - | - | - | - | | - | - | - |
| Total | 1,077 | 982 | 1,013 | 1,140 | 1,181 | 1,215 | | (63) | (200) | (202) |
| **National** | | | | | | | | | | |
| Bituminous | 12,940 | 14,114 | 15,153 | 13,117 | 13,570 | 14,418 | | (177) | 544 | 735 |
| Subbituminous | 8,990 | 9,995 | 10,680 | 8,989 | 10,813 | 11,683 | | 1 | (818) | (1,003) |
| Lignite | 774 | 774 | 774 | 801 | 801 | 801 | | (27) | (27) | (27) |
| Total | 22,704 | 24,882 | 26,607 | 22,908 | 25,184 | 26,902 | | (203) | (302) | (295) |
| **Impact of CAIR/CAMR** | | | | | | | | | | |
| | (ii) Base Case with CAIR/CAMR | | | | (i) Base Case without CAIR/CAMR | | | | Delta (ii - i) | |
| **IL State** | | | | | | | | | | |
| Bituminous | 201 | 214 | 212 | 220 | 243 | 280 | | (18) | (29) | (68) |
| Subbituminous | 924 | 942 | 942 | 920 | 938 | 936 | | 4 | 3 | 6 |
| Lignite | - | - | - | - | - | - | | - | - | - |
| Total | 1,126 | 1,156 | 1,154 | 1,140 | 1,181 | 1,215 | | (14) | (26) | (62) |
| **National** | | | | | | | | | | |
| Bituminous | 12,945 | 14,070 | 15,068 | 13,117 | 13,570 | 14,418 | | (172) | 500 | 650 |
| Subbituminous | 8,990 | 10,053 | 10,701 | 8,989 | 10,813 | 11,683 | | 1 | (760) | (981) |
| Lignite | 792 | 792 | 792 | 801 | 801 | 801 | | (10) | (10) | (10) |
| Total | 22,727 | 24,915 | 26,560 | 22,908 | 25,184 | 26,902 | | (180) | (269) | (341) |

Table 9.11 summarized coal plant retirements resulting from the rule. IPM retires units when it is uneconomic for them to continue operation, in comparison to the alternatives of running existing units harder, building new units, and when considering whether their continued operation is required for reserve margin purposes. This decision reflects the situation over the entire study horizon. Relative to the CAIR/CAMR case, the Policy Case results in a small amount of coal-fired capacity to be uneconomic and thus retire (252 MW). These plants are Hutsonville Units 5 and 6 (partial) and Meredosia Units 1-4. These units are currently 50 years old or older. In practice, units that become uneconomic when the rule takes effect may be "mothballed" until fuel prices or other conditions change, they may retire, or may be kept in service for grid reliability purposes.

**Table 9.11**
**Cumulative Coal Plant Retirements (MW)**

| | (iii) Policy Case with IL Rule | | | (ii) Base Case with CAIR/CAMR | | | Delta (iii - ii) | | |
|---|---|---|---|---|---|---|---|---|---|
| Plant Type | 2009 | 2015 | 2018 | 2009 | 2015 | 2018 | 2009 | 2015 | 2018 |
| IL State | | | | | | | | | |
| Coal | 597 | 597 | 597 | 345 | 345 | 345 | 252 | 252 | 252 |
| National | | | | | | | | | |
| Coal | 2,085 | 2,788 | 2,788 | 1,880 | 2,585 | 2,585 | 205 | 203 | 203 |

* Retirement figures are cumulative.

### 9.3 Conclusions

ICF identified the principal findings of the study as:

- The proposed Illinois Mercury Rule reduces coal-fired generation in Illinois by 15 percent in 2015 (7 percent reduction in total generation). This generation lowers exports to neighboring regions.
- Total production costs in the region increase by about 2 percent in the first year of the policy. However, in subsequent years, costs fall as exports fall and associated

production costs offset compliance cost increases. This also implies that revenues from exports fall.

- Average production costs in Illinois increase 2-3 percent as a result of the rule. Marginal prices increase 2-4 percent across the study period.

- Mercury emissions drop to 883 pounds of mercury by 2009, 84 percent below levels under the CAMR. By 2018, they fall to 799 pounds, 58 percent below CAMR levels.

- The retail electricity prices and costs across all sectors (residential, industrial and commercial) are higher as a result of the rule relative to the CAMR, but by only a small percentage – 1 to 3.5 percent over the study horizon. On an average bill basis, residential customers pay less than $1.50 per month more under the Illinois rule relative to CAMR across the study horizon.

## 10.0 Other Relevant Issues and Additional Considerations

This section addresses several issues that were contemplated, researched, and discussed during the course of developing the proposed Illinois mercury rule. This section also expounds upon previously addressed issues in this document.

### 10.1 Clean Air Interstate Rule (CAIR)

In May 2005, USEPA issued in final form the CAIR to regulate NOx and SO2 emissions from the eastern region of the United States. Illinois is currently finalizing a regulatory proposal to satisfy the requirements of the CAIR and will be submitting the proposal to the Board shortly after the submittal of the mercury rule.

IPM shows that the costs attributed to the implementation of the CAIR rule in Illinois are far greater than those of the mercury rule. In essence, the modeling shows that the cost effects associated with the CAIR rule on electric rates and the power sector are several orders of magnitude higher than those of the proposed Illinois mercury rule. The benefit-cost analysis performed by USEPA for CAIR shows that substantial net economic benefits to society are likely to be achieved due to reductions in emissions resulting from CAIR.

## 10.2 Safety and Reliability of the Electricity Distribution Grid

As a matter of general grid safety, all generation units in Illinois, regardless of generation source, are required to meet specific worker and public safety standards. These standards are administered by various organizations including the Illinois Commerce Commission (ICC), the Occupational Health and Safety Administration (OSHA), and the National Electric Safety Code. Under no scenario is a generation facility allowed to compromise its obligation to adhere to worker and public safety requirements.

A concern in developing the proposed rule was the effect, if any, the rule would have on the reliability of the electrical grid. This concern manifests when the costs for mercury controls are so large that they would cause the shutdown of some EGUs or even some power plants. Illinois addressed this issue by examining the likelihood of the proposed mercury control requirements resulting in unit and/or plant shutdowns using the IPM and by consulting with experts who have the responsibility for ensuring the safety and reliability of the grid.

For background purposes, the electric utility industry initially developed as a loosely connected network of individual companies, each building power plants and distribution and transmission lines to serve a franchised service territory. Over the years, the industry has undergone many changes with more changes expected in the near future. As time passed, the individual transmission systems were integrated with others to improve reliability and facilitate transfer of power across companies. Illinois became part of the Mid-America Interconnected Network (MAIN) in the Eastern Interconnect. Regional Transmission Organizations (RTOs) were also created in order to facilitate cooperation between power companies. Illinois power plants are members of two different RTOs. The area generally served by Commonwealth Edison is in the PJM Interconnection (PJM) and the remainder of the state is in the Midwest Independent System Operator (MISO) territory. The federal and state governments also regulate wholesale and retail electricity pricing. The Federal Energy Regulatory Commission (FERC), among other responsibilities, oversees the transmission and wholesale sales of electricity in interstate commerce. The ICC regulates the retail aspect of the business. RTOs play a major role in assuring the reliability and safety of Illinois' power grid.

The reliability of the transmission system depends upon critical voltage support and resource capability at key locations in the grid. Actions that lead to reductions in these critical factors can ultimately cause widespread service interruptions or exacerbate a failure of the grid as witnessed in the northern portion of the U.S. and parts of Canada during August 2003. The August 2003 blackout extended to eight states and was not completely restored for days to weeks depending on the affected area. Costs to residents in the affected areas were estimated at $6.4 billion. The August 2003 power outage demonstrates the importance for Illinois to have a reliable power supply. During such outages it is essential that "blackstart" units or plants are available to assist in restoring the grid. A blackstart unit is defined as a generating unit that is able to start without an outside electrical supply or the demonstrated ability of a base load unit to remain operating, at reduced levels, when automatically disconnected from the grid. A blackstart plant is simply a generating plant that includes one or more blackstart units.

Grid congestion problems can become particularly acute where certain generating plants must run because their operation is essential to maintaining grid reliability. Certain older power plants in Illinois are categorized as "must run" in that they would need to remain in operation at least through 2008 to maintain grid reliability principally because they supply needed voltage support.

Although several state-sponsored initiatives have been launched since 1999 to encourage development of new plants firing Illinois coal, no additional base-load or replacement generating capacity is under construction. While construction permits have been issued for three new plants, the permits are not yet effective because they have been challenged by a number of environmental groups. At this time, Illinois cannot rely on any new baseload generating capacity in the near future. Also, no significant construction to address transmission grid reliability issues is known to be planned within the State or within the MAIN electric transmission region.

Given these issues, the Illinois EPA consulted the State's two RTOs to better understand any effect the proposed mercury rule would have on grid reliability. Although the RTOs generally found that accurate predictions are extremely difficult to make, there were no significant concerns expressed in regards to the reliability and safety of Illinois' power grid resulting from the proposed mercury rule. Illinois has two must run coal-fired power plants, one of which is also a blackstart plant. Analysis shows that these plants should be able to comply with the proposed rule utilizing a cost-effective strategy for mercury control, such as installation of halogenated PAC. Predictive modeling performed (IPM) indicates that these plants will continue to operate and would not be shut down as a result of Illinois' proposed mercury rule.

The North American Electric Reliability Council, which governs reliability issues, requires the RTOs (PJM and MISO) carry 15% of peak capacity in reserve. Because of this requirement, the scenario in which the reliability of the Illinois electric grid (or the nation's electric grid for that matter) would be in question would be one in which more than 15% of all generating units in the state were to unexpectedly and simultaneously shut down. Were that to occur, the reserve margin would potentially be exceeded and reliability could be compromised. Numerous economic incentives, physical safeguards, and regulatory requirements make such a scenario extremely unlikely.

Because of the strong economic incentive for a generation unit to run during periods of peak load, it is also unlikely that any plant operator would choose to take a unit off line to install a mercury control device during that time and even less likely that all plant operators in the state would choose to do so simultaneously. Furthermore, because of the capacity payment structure PJM and MISO provide to generation units, there is a strong economic incentive to keep units available to run during peak load times. Note that the service outage that would occur to install either an ACI system or ACI and a fabric filter is quite small.

### 10.3 Potential Economic Benefits Other Than Health Related

There will be several recognized benefits to the State from tighter mercury controls. Such benefits include reduced risk to public health and welfare and an increased potential for the support of existing jobs and addition of new jobs resulting from the installation and operating requirements for additional pollution control devices. There also exists a potential for an increase in tourism and recreational fishing as mercury levels drop in fish, bringing an associated positive impact to local economies and the State overall.

Any improvement, or prevention of loss, to Illinois' fish and wildlife activities through implementation of Illinois' mercury rule could have a positive impact to this important industry. The most recent survey conducted by the U. S. Fish and Wildlife Service indicates that more than 4.5 million people participated in wildlife-associated recreation activities in Illinois in 2001, including fishing, hunting, and bird watching. Expenditures for trips and equipment for these activities in Illinois included $1.35 billion for fishing and hunting, and $596 million for wildlife watching (activities such as observing, feeding, and photographing wildlife). All told, wildlife-associated recreation expenditures in Illinois contribute more than $1.9 billion to the State economy. The American Sportfishing Association took the U. S. Fish and Wildlife Service data one step further and analyzed the broader economic impact of sportfishing in Illinois (including sportfishing in the Great Lakes) to be worth more than $1.6 billion to the State economy when considering the salaries from jobs created, as well as sales and motor fuel taxes, and State and federal income taxes.

**Table 10.1 Economic Information on Sportfishing in Illinois for 2001**

| Economic Output | Retail Sales | Salaries and Wages | Jobs | Sales and Motor Fuel Taxes | State Income Taxes | Federal Income Taxes |
|---|---|---|---|---|---|---|
| $1,623,449,163 | $736,575,125 | $398,275,277 | 12,886 | $50,445,665 | $9,377,569 | $73,123,710 |

NOTE: The figures above only include fishing activity attributed to anglers 16 years old and older. There are additional economic impacts generated by minors.
The expenditures reported here are greater than those reported by the U.S. Fish and Wildlife Service. Sportsmen often attributed purchases to both fishing and hunting (especially vehicles and big-ticket items). These items were not included in the Service's fishing expenditure estimates. Such items were included above by prorating each item's cost based on each respondent's total days of hunting and fishing activity.

## 10.4 Potential Effect of Activated Carbon Injection (ACI) on Particulate Matter (PM) Emissions

A concern was expressed during the stakeholder meetings regarding the potential for increases in the emissions of PM and other pollutants from the flue gas stacks due to the use of ACI. In particular, an increase in PM emissions, and associated opacity, has been theorized due to the additional particulate loading to an existing electro-static precipitator (ESP) after the upstream injection of sorbent and the inability of the ESP to accommodate and adequately control the additional particulate load.

Field testing of ACI systems at boilers with ESPs has not validated increases in PM emissions as a common, or even likely, occurrence. Despite numerous tests with halogenated activated carbon, none of these tests have shown any adverse effect on cold-side or hot-side ESP performance. Of the dozens of sorbent injection field test programs that have been performed, only two have shown any adverse impact on ESP performance or PM emissions – and these tests were performed with untreated powdered activated carbon (PAC) at injection rates many times greater than the treatment rates that would be necessary with halogenated PAC. Therefore, there is no reason to expect that proper use of halogenated PAC for mercury control will cause any PM emission problem.

A review of a scenario where typical levels of halogenated PAC are injected to achieve a high level of mercury control in conjunction with an ESP shows that the amount of sorbent is very small in comparison to the loading of particulate contained in the flue gas stream. For a typical coal-fired boiler, the increased loading to the ESP from sorbent would be less than one percent. Even for a cyclone-fired boiler that reinjects fly ash, in which more of the ash leaves the boiler as bottom ash, the increased loading to the ESP from sorbent would be less than five percent. According to EIA form 767 data, there is only one unit in Illinois (i.e., SIPCO's Marion 1 unit) that reinjects fly ash. This unit is not expected to require sorbent injection due to very high mercury removal as co-benefit of other controls.

The loading of particulate entering into ESPs at coal fired utility boilers is measured in thousands of pounds, orders of magnitude greater than the rates at which sorbent is injected with ACI. Day to day variations in coal likely far exceed the additional loading from sorbent. Testing of PM emissions of the coal-fired boilers in Illinois shows that existing ESPs routinely comply with the applicable PM emission standards by an ample margin of compliance. As such, the effect of sorbent injection on overall PM emissions, as well as opacity, from a coal-fired utility boiler should be negligible. Of note is that the amount of sorbent needed to achieve a high level of mercury control reaches a plateau such that there is little additional control beyond a given rate of injection. This, along with the cost benefit of using as little sorbent as possible, will serve to provide incentive for company's to use the most effective level of sorbent possible as opposed to high or excessive levels.

If an increase in PM emissions would occur, it is believed it would be minimal, again due to the small addition to the particulate loading to the ESP from sorbent injection. However, in the unlikely scenario that installation of an ACI system could result in a measurable increase in PM emissions, there are several options available to the source. First, the source could appropriately manage the rate of sorbent injection to assure that the increase in PM emissions would not reach the level at which it would be considered significant for purposes of New Source Review. The annual thresholds for a significant increase in PM emissions are 25 tons of PM and 15 tons of PM10, which means that the hourly increases in emissions would have to be more than five pounds of PM or three pounds of PM10 before the increase would be considered significant. Second, the source could "tweak" the ESP to compensate for some or all of the potential increase in PM emissions. This could be accomplished by relatively simple means, such as improvements in operating and maintenance practices for the ESP, enhanced use of a flue gas conditioning system, if one is present, or installation of one of a variety of upgrades that is available for an existing ESP, such as an agglomerator or skewed gas flow. Finally, for units located in areas that are attainment for the PM2.5 air quality standard, a source could obtain a permit for a major modification under the PSD program, which would accommodate a significant increase in PM emissions. PSD review does allow for considerations of the overall net benefit of a project. Although PSD permitting can be a lengthy process, especially if a permit is challenged, a PSD permit could in all likelihood eventually be issued to allow for any incidental increase in PM emissions accompanying use of ACI for control of mercury emissions.

Likewise, ACI systems should have no adverse impact on emissions of other pollutants from power plants, such as sulfur dioxide or nitrogen oxides, or their associated controls.

### 10.5 Illinois Coal Industry Considerations

At the end of 2003, coal production in Illinois totaled 31.1 million tons, down more than 2.3 million tons from 2002. The loss of coal mines and coal mining jobs has had a significant negative impact on the economic structure of southern Illinois. Although mining salaries doubled between 1980 and 2003, from $22,000 a year to $45,500 a year, the total economic payroll of the mining industry in Illinois decreased by 60 percent during the same time period. Moreover, until the adoption of CAMR the regulatory climate concerning Illinois coal remained uncertain with mixed signals from the federal government over proposed mercury reduction standards that would serve to benefit western coal, again at the expense of coal mined here in Illinois.

Bituminous coal is generally mined in states east of the Mississippi river, including Illinois, and is referred to as "eastern coal," while the majority of the coal mined west of the Mississippi river can be classified as either sub-bituminous or lignite coal, and is called "western coal".

Similar to other forecasts, the impact of the proposed Illinois mercury rule on the coal industry in Illinois is difficult to determine. This is true due to the ultimate decision on how a source will comply being at the discretion of the source. The rule does not mandate the use of any specific type of coal or control device. However, the rule does seek to treat all coals in a comparable manner, while acknowledging and providing credit for existing coal washing operations being performed that reduce the mercury content in coal, and hence mercury emissions.

The proposed Illinois rule is fuel-neutral in that it is not biased towards any particular coal type. The rule does not treat sources differently or establish different requirements based on the type of coal being used. This is contrary to CAMR, which established State mercury budgets, as well as proposes a baseline allocation scheme, that provides higher allowances for units burning coal types other than bituminous. For example, CAMR established Illinois and other state budgets by multiplying each units baseline by 1.0 for bituminous coal, 1.25 for sub-bituminous, and 3.0 for lignite. This methodology obviously provided higher allowances to sources using western coals and was thus considered to benefit sources that utilized western coals, and perhaps thereby encouraging a shift to use such coals. The proposed Illinois mercury rule does not contain this favorable "bias" toward western coals. This may be of particular significance since recent advances in mercury control technology have substantially improved the ability and cost-effectiveness of controlling mercury emissions for sources using western coals, whereas the inability to control western coals as readily and cost effectively as bituminous coals was one of the stated reasons why the weighted allowance scheme was adopted in CAMR.

Furthermore, the proposed Illinois rule allows for compliance with an output-based standard in recognition of coal washing. This optional compliance standard recognizes pre-combustion mercury removal due to coal washing. Eastern or bituminous coals such as those mined and sold in Illinois are currently washed whereas western coals are not.

Through the aforementioned mechanisms, Illinois has sought to eliminate any unwarranted incentive of the proposed rule toward the use of subbituminous or lignite coals, and thus cause any harm to the Illinois coal industry. In fact, predictive IPM modeling shows an increase in the use of bituminous coal as a direct result of Illinois' proposed mercury rule. This increase should have a positive impact on Illinois coal related operations, such as Illinois coal mines and jobs, since most of the bituminous coal fired in Illinois is mined in Illinois. The modeling also shows a corresponding decrease in the use of subbituminus coal, which is mined in western States. Of particulate interest is that were Illinois to implement CAMR instead of the proposed mercury rule, IPM modeling shows a decrease in bituminous coal use.

### 10.6 Effect on other Pollutants and Upcoming Regulations

The proposed mercury rule will be in addition to other existing rules and will not supersede or replace any other rule regulating air emissions from EGUs. In particular, the Illinois EPA looked at the effect the proposed mercury rule could have on CAIR and multi-pollutant control strategies. The costs of mercury specific controls are relatively low in comparison to the costs of CAIR compliance and controls. Sources may elect a multi-pollutant control strategy that should allow them to achieve all of the mercury control required as a co-benefit of the installation of controls needed to comply with CAIR (e.g., scrubbers and SCRs). IPM modeling shows that under the proposed rule some EGUs will expedite planned installations of, or elect to install, scrubbers as a result of Illinois' rule. The modeling does show a negative impact to scrubber installation after the initial period modeled. The modeling also shows that the rule results in some SCRs not being installed.

### 10.7 Shutdown and Replacements

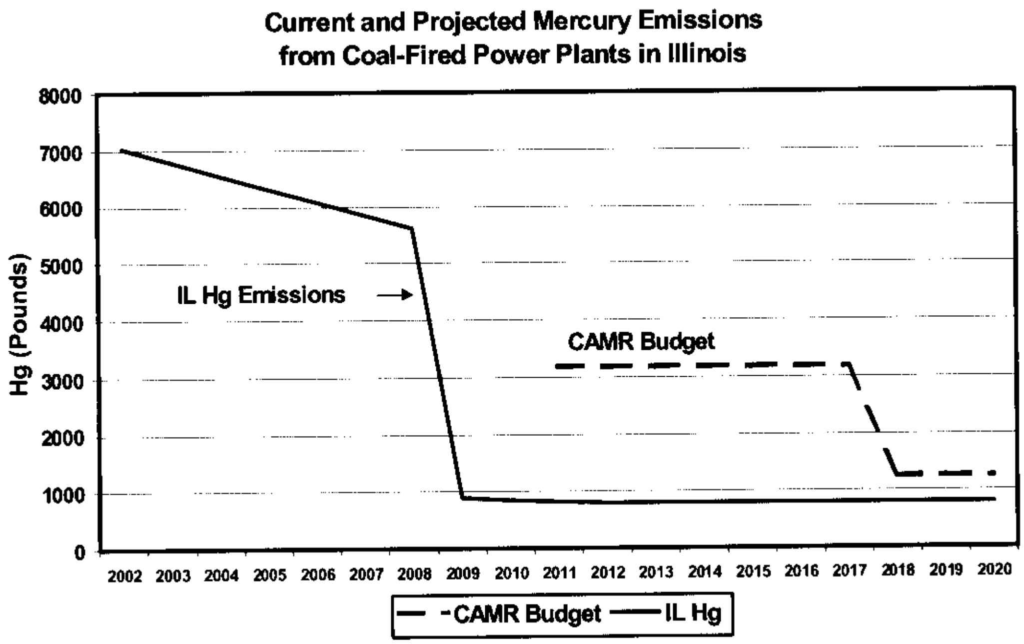
Illinois designed the proposed rule so that EGUs targeted for permanent shutdown or replacement within a relatively short timeframe after the initial compliance date of the rule are not required to comply with the control requirements and are likewise excluded from compliance calculations. This provision is intended to allow sources to avoid unnecessary costs and expenditure of resources. Once such units are permanently shutdown they will obviously emit no mercury and any interim level of control achieved between the compliance period and final shutdown would have been minimal.

## 10.8 Compliance with CAMR

The CAMR requires that Illinois reduce and maintain mercury emission levels from coal-fired EGUs at or below 3,188 pounds per year beginning in 2010. Under CAMR, mercury emissions from all coal-fired EGUs statewide are budgeted at 1,258 pounds annually beginning in 2018.

Even though Illinois' proposed mercury rule requires greater mercury emission reductions, and requires that the reductions be achieved sooner than CAMR, the proposed rule does not impose an "emissions budget" as established by the federal rule. Potentially, future growth of electric generation by coal-fired EGUs in Illinois could cause mercury emissions to increase above the level of the CAMR emissions budget. Although CAMR does not require a state to adopt a cap and trade program, the rule does require that a state not using the cap and trade provisions demonstrate that it will not exceed the budget. Illinois will submit a plan that ensures that the State's CAMR emissions budget will never be exceeded. Illinois has prepared a projection of expected mercury emissions in Illinois from coal-fired EGUs for the first 10 years of the CAMR program (2010-2020) that projects Illinois mercury emissions will remain below budget levels during this period (see Figure 10.1). This is based on projected growth in coal consumption by EGUs during this timeframe and the control requirements contained in Illinois' proposed rule.

**Figure 10.1**




Further, Illinois EPA will commit to provide to USEPA on an annual basis beginning in 2011, subsequent to the first year of the CAMR program, a report that tabulates mercury emissions reported by the affected emission sources for the preceding year to demonstrate that actual emissions have not exceeded the State's CAMR emissions budget. The annual report to be submitted by Illinois EPA will also include a projection of mercury emissions from coal-fired EGUs in Illinois for the next 10-year period. In the event that annual emissions exceed the applicable CAMR mercury budget, based on either the previous year's reported emissions or on the 10-year projection, the Illinois EPA will take corrective actions to limit mercury emissions as needed to comply. The corrective actions may include submission of more stringent emission limitations to the Illinois Pollution Control Board and to USEPA. Illinois' commitment to prepare the annual report, including the 10-year projection, and to take corrective actions in the event that the CAMR budget is exceeded is an integral part of Illinois' plan, and will be submitted to USEPA as a SIP revision.

## 10.9 Hot Spots

There are several uses of the term "hot spots" in the literature addressing mercury emissions with no known formal definition. A common use of the term hot spots is to define areas that show up on mercury deposition maps as red, where red areas indicate locations of high mercury concentrations. The term is also used to define areas in a cap and trade program where reductions are less likely to occur due to allowances being purchased or use of banked allowances in order to avoid mercury reductions and/or installation of mercury controls. In any event, the Illinois proposed rule addresses this potential situation by not allowing trading, or the banking or purchase of allowances, and by requiring mercury reductions at all power plants. The emission reductions required by the proposed rule will occur in Illinois and at all locations where power plants exists and thereby address the issue of local impacts and hot spots.

## 10.10 Temporary Technology Based Standard (TTBS)

Illinois had considered the possibility of including a TTBS to provide additional regulatory flexibility for compliance with the rule. This concept was presented at several of the stakeholder meetings. A limited number of comments were received with no stakeholders stating that this provision would be utilized.

One potential application of the TTBS concept would be to address the compliance of EGUs that are equipped with hot-side ESP's. Units with hot-side ESP's, and no SO2 or NOx controls, would likely not be able to achieve a 90% reduction with the installation of halogenated PAC alone. Nonetheless, those EGUs would be able to achieve a 90% reduction with the installation of a fabric filter along with ACI. Note that 90% mercury reduction without the addition of a fabric filter may be achievable on such units in the future from additional sorbents and optimization techniques that are currently being developed and tested.

The number of EGUs that may be required to install fabric filters in order to achieve compliance is very limited. Illinois currently has three EGUs with hot-side ESPs. One EGU is already required to install a fabric filter pursuant to an existing judicial consent decree, although the installation date would need to occur around 2 ½ years earlier than required by the consent decree. Of note is that the public health and environmental benefits would be achieved sooner. The costs of installation of a fabric filter at each of the two remaining units with hot-side ESP's could be amortized over a number of years and balanced against the numerous remaining EGUs under ownership by the same company where fabric filters are less likely to be required.

Furthermore, there is flexibility built into the proposed rule to help negate the need for a temporary standard. Each phase of the rule allows some form of aggregate compliance or averaging, with the first compliance period allowing the use of system-wide averaging. That makes it permissible for select plants to achieve only a 75% reduction so long as the system-wide average is 90%. Additional flexibility is also built into the rule with the alternate output-based standard.

This is approach is also consistent with the recommendation made by STAPPA-ALAPCO, as no such technology-based mechanism is built into its mercury reduction model rule. Consequently, after further review and consideration, Illinois has decided to not include the TTBS provision in the rule.

## 10.11 Effect on Illinois Jobs

### 10.11.1 Power Sector Jobs

According to industry estimates, there are approximately 4,100 jobs directly involved in operating Illinois power plants. In addition, approximately 6,000 more jobs provide skilled contractual labor and miscellaneous support. These jobs produce a combined payroll and benefits that amount to over $700 million a year for employees. There are also another 5,500 retirees whose health insurance could be impacted by the financial viability of the power plants. Furthermore, the approximate value of goods and services purchased locally related to these jobs is over $300 million. Illinois' coal-fired power plants pay about $21 million a year in property taxes to local taxing bodies, the majority of which goes to support local school systems.

A concern raised was that an EGU or power plant would potentially need to shutdown as a result of the costs of complying with the proposed Illinois mercury rule. This of course would likely lead to job loss. Illinois EPA must emphasize that it is clearly not the intent of the proposed mercury rule to impose costly standards that result in EGUs shutting down and thereby causing any corresponding job loss. As indicated in Section 7, measures were taken, such as inclusion of broad flexibility, to minimize the likelihood of any such scenario occurring. The proposed rule does not mandate the shutdown of any EGU or power plant. Instead, the rule requires compliance with a standard and provides flexibility on how compliance with that standard is achieved. The proposed rule does not prescribe how compliance is to be achieved and in not doing so allows companies the opportunity to explore and select the most cost effective approach to obtaining compliance. The Illinois EPA believes that cost-effective mercury controls are available and can be readily installed for compliance purposes. Of note is that the costs associated with mercury specific controls are magnitudes lower than the costs associated with the control devices for other pollutants, such as a scrubber for SO2 control or SCR for NOx control.

The IPM does forecast that some coal-fired units become uneconomic as a result of Illinois' rule and are therefore retired. In practice, units that become uneconomic when the rule takes effect may be "mothballed" until fuel prices or other conditions change, they may actually be retired, or they may be kept in service for grid reliability purposes. The model shows that this is a concern for six EGUs, consisting of the two units at Ameren's Hutsonville plant and four smaller units at Ameren's Merodosia plant.

Hutsonville operates two very old units of around 76 MW each, which were constructed in 1952 and 1953. These two units comprise all the units at the plant, however, IPM predicts only "partial" retirement of unit 6, and therefore it cannot be concluded that the plant will shutdown. In explanation, IPM is a linear programming model, not integer.

The implication is that when IPM makes a decision that affects units (e.g., retires, builds, retrofits) it doesn't do it in "whole units". For example, IPM might show the construction of a 250 MW coal-fired unit when, in fact, the smallest size that could be built in practice would be 500 MW. IPM makes predictions and works linearly or continuously. Therefore, IPM may retire a unit "partially" or, using the example, it may retire only 250 MW of a 500 MW unit. The implications to the Hutsonville plant of only partial retirement of a unit as opposed to full retirement is that there is an increased likelihood that some portion of the plant would remain economical to continue operation and not be fully retired. This could result in the plant remaining open and not shutting down.

The Meredosia plant consists of four small, very old units of 31 MW each constructed in 1945 and 1946, and one larger unit of around 239 MW constructed in 1957. IPM shows the four smaller units retiring and the larger unit continuing to operate. Since the larger unit is forecasted to continue operation, IPM does not predict that this plant would shut down.

Below is information on the annual operating hours of the retired units, out of a possible 8,760 hours per year.

**Table 10.2 Annual Operating Hours Based on Acid Rain Data**

| Plant | Unit | 2005 | 2004 | 2003 |
|---|---|---|---|---|
| Hutsonville | 5 | 7,145 | 6,888 | 7,024 |
| | 6 | 6,962 | 7,374 | 7,322 |
| | | | | |
| Meredosia | 1 | 3,213 | 2,136 | 1,701 |
| | 2 | 3,141 | 2,551 | 2,089 |
| | 3 | 2,145 | 2,449 | 1,709 |
| | 4 | 3,273 | 2,741 | 2,281 |

Obviously there is the potential for jobs to be lost should these retirements occur. The Hutsonville and Meredosia plants are estimated to have around 60 and 100 employees, respectively.

**10.11.2 Coal Industry Jobs**

Concern has also been expressed in the area of detrimental impacts from the proposed rule to the Illinois coal industry and related jobs. As previously identified, Illinois has lost a significant number of coal mines and coal mining jobs since 1980. This loss has had a negative impact on the Illinois economy, especially in southern Illinois. The modeling used to forecast the proposed mercury rule's effect shows an increase in the use of bituminous coal due to the proposed mercury rule when compared to CAMR, and also when compared to no mercury control, projected out to 2015. Such an increase should have a positive impact on Illinois coal related operations, such as coal mines and jobs, since most of the bituminous coal fired in Illinois is mined in Illinois. The increase in bituminous coal demand would logically result in an increase in the need to supply the coal, triggering a stimulus for either higher production at existing mines or the opening of new mines, thus resulting in support for existing jobs and the potential for new jobs. It is important to note that the modeling shows a negative impact, or decrease, in bituminous coal use if Illinois implemented CAMR instead of it's proposed rule. Therefore, the proposed Illinois rule is forecasted by IPM to essentially reverse the impact to bituminous coal use in Illinois from a negative to a positive outcome, i.e., instead of less bituminous coal use due to mercury control through CAMR, there should instead be more bituminous coal use due to mercury control through Illinois' proposed mercury rule.

#### 10.11.3 Other Jobs

Another of the concerns regarding a possible negative impact of the proposed Illinois mercury rule on jobs in Illinois rests with the belief that job loss would result from higher electricity rates. Jobs cuts would then potentially occur from industrial and commercial facilities going out of business or from layoffs made to offset increased costs from such facilities having to pay higher electricity rates. IPM modeling shows an incremental increase of one to two percent for industrial electricity rates, and one to three and a half percent for commercial electricity rates as a result of Illinois' proposed mercury rule. The effect on jobs from these incremental increases is difficult to determine, however, the percentage increases are small.

One area that should see a beneficial impact to jobs from Illinois' proposed mercury rule are those construction and maintenance jobs associated with mercury control devices, such as halogenated ACI. Also, if the fishing and tourism industries are positively impacted by the proposed rule, then it is reasonable to conclude that this would provide support for existing jobs, as well the potential for new jobs, to provide the appropriate related services, such as increased sales in fishing equipment.

**10.12 Effect on Electricity Rates**

Careful consideration was given to the effect Illinois' proposed mercury requirements will have on Illinois' economy in the form of any increase to the electric rates paid by residential consumers as well as industrial and commercial facilities.

IPM results show a small incremental impact to Illinois electricity rates from the proposed mercury rule requirements when compared to the impact expected from the federal CAMR. In particular, the modeling projects an approximate increase in residential electric bills of less than $1.50 per month, or $18 per year, or about one to two percent. Retail electricity prices as well as costs across all sectors (residential, industrial and commercial) are higher as a result of Illinois' rule relative to CAMR by about one to three and a half percent over the length of the study. The modeling also showed that the effects on rates from either of the modeled mercury rules (i.e., CAMR or Illinois' proposed rule) were small in comparison to the effect attributed to the federal CAIR. This would be expected since compliance with the CAIR requirements is generally considered to be more costly, in part due to installation of controls that are much more expensive than mercury specific controls, as well as CAIR being for multiple pollutants (i.e., NOx and SO2).

Illinois had also conducted a previous modeling run utilizing IPM to provide insight on, among other things, how a 90% mercury control requirement in Illinois phased in from 2009 to 2012 would impact Illinois consumer electric bills. This run also found a small impact to rates when compared to the impact expected from CAMR. Specifically, results showed a similar increase to residential consumer electric bills of around $6 per year for 2009 and $15 per year for 2012.

Other studies have found similar impacts to electricity rates resulting from 90% mercury control in Illinois. The National Wildlife Federation's (NWF) report, "*Getting the Job Done: Affordable Mercury Control at Coal-Burning Power Plants*" (October 2004) provides cost estimates for 90% mercury control at power plants in Illinois. The NWF cost estimates are based on an assumption that activated carbon injection and a polishing fabric filter would be needed to reliably reach 90% mercury capture at most boilers in Illinois. NWF applied USEPA cost estimates for these technologies and power plant configurations to calculate the cost of retrofitting Illinois' power plants. NWF estimated that total annual cost of 90% mercury control at $138.9 million dollars.

The study further estimated an increase to the average residential household electricity rate in Illinois at $0.69 per month, or about 1.1% of the existing electric bill. This equated to roughly 0.1 cent/kWh. The study found that the difference in costs from 70% to 90% was not significant. This study is consistent with at least two other cost studies performed, namely; 1) Institute for Clean Air Technologies, 1.3% – 3.7% increase in rates, and 2) Department of Energy, 0.13 to 0.24 cents per kWh for mercury control ranging between 60 – 90%.

The 2004 NWF study found the affect to commercial and industrial electric bills were a similar 1% increase, adding approximately $5.82/month and $305.47/month, respectively. A notable factor when reviewing the NWF study is that it assumed that a power plant equipped with only an ESP would install both ACI and a polishing fabric filter regardless of coal type, an assumption that would lend the results to be conservative. Recent tests have shown that halogenated PAC and a cold-side ESP are capable of high mercury control without the addition of a polishing fabric filter, a particulate control device with a capital costs at least 10 times greater than the mercury specific halogenated PAC.

## 10.13 Other Considerations and Influencing Factors on the Costs of Electricity

There are several factors outside of the proposed mercury rule that stand to play a large role in determining the cost of electricity in Illinois over the coming years. Illinois sought to analyze such factors and review the effect or role that the proposed mercury rule had in conjunction with some of these driving factors.

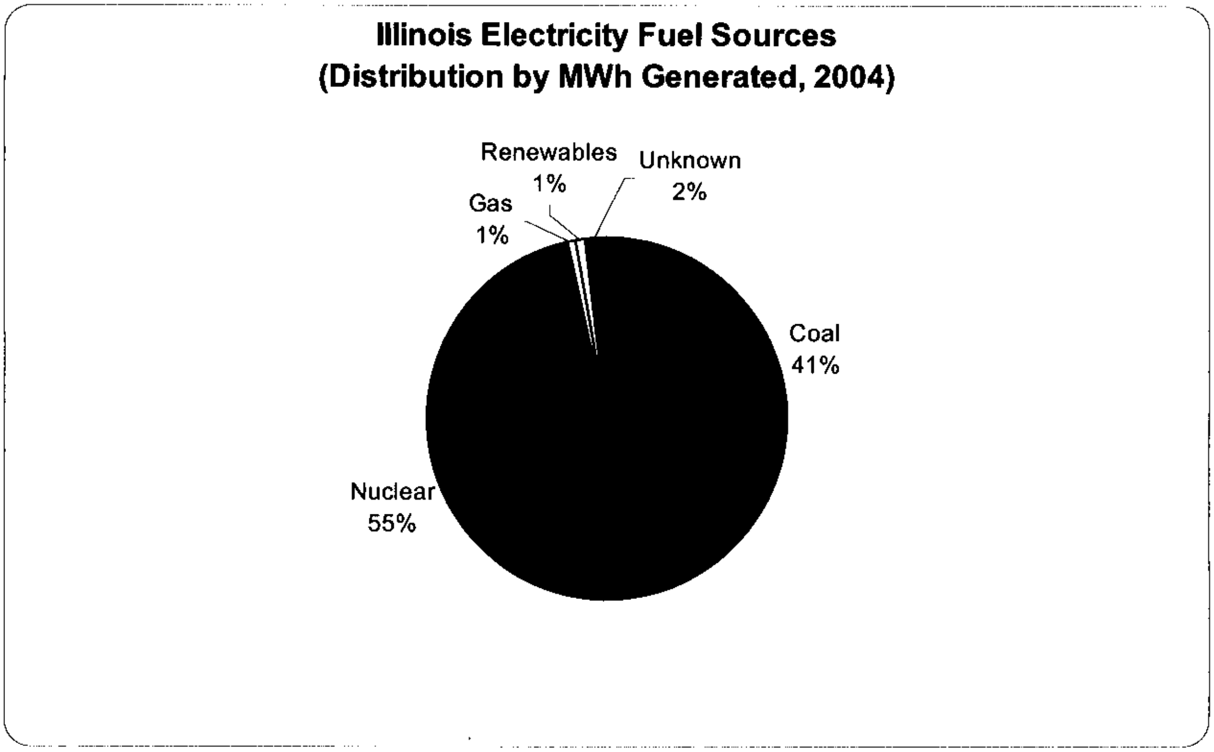
### 10.13.1 Lifting of Rate Freeze and Deregulation

Illinois is scheduled to lift a 10 year cap or freeze on retail electricity rates in January 2007. As Illinois utilities move towards an auction-based procurement methodology through the deregulation process now underway, all generators will be able to choose how and where they bid their electricity into the auction. Some generators may analyze their options and choose not to bid into the utility auction and may instead choose to sell their power directly into the RTO markets on a day ahead or real time basis. Regardless of any generator's decision, the cost of electricity to retail customers, especially residential and small business customers, will continue to be regulated by the Illinois Commerce Commission (ICC) through tariffed rates. The ICC is still debating various proposals on the absolute effect of the auction outcome on residential and small business customers. Independent of the ICCs decision, the effects of the proposed mercury control requirements are difficult to determine.

### 10.13.2 Power Generation from Sources Other than Coal-Fired Utilities

The ICC sets rates for residential and small business customers. The ICC has approved a procurement plan for Illinois starting January 1, 2007, which will likely cause electric rates to rise but that outcome has no connection to the proposed mercury rule requirements. In fact, electric generation in Illinois is today, and will likely continue to be, dominated by nuclear power (see Chart 1), a form of generation that is not subject to the proposed mercury control rule. In 2004, 55% of the megawatt hours generated in the State were from nuclear resources while 41% came from coal. Due to the heavy reliance on nuclear energy in the State, the impact of the proposed mercury rule is minimized to the extent that it does not impose additional requirements and associated costs on the largest source of power generation in the state.

**Figure 10.2 Illinois Electricity Fuel Sources**




### 10.13.3 Interstate Competition

The effects of the proposed mercury rule on the ability of an Illinois coal-fired power plant to effectively compete in the interstate trading of electricity is difficult to determine. Illinois is served by two transmissions organizations (PJM and MISO) that set both the rules for the fair transmission of electricity and provide the financial marketplace for the dispatch of power on a minute-to-minute basis. PJM and MISO set the price of power based on the demand for power. As demand for power increases, the value of power increases. Generators tell the market operators a day ahead (or in real time) the price they are willing to sell at to run their facility. The generator is only obligated to run their facility if they have committed to run their facility. The operating cost of every generation unit in the country is different because each plant's debt structure, regulatory compliance cost, labor, maintenance, and a myriad of other costs are site specific. The implementation of the proposed mercury rule in Illinois may change the cost structure of a plant in a way that makes it more or less competitive as it bids into a transmission market. The costs associated with the installation and operation of mercury controls have been thoroughly addressed in this document.

The minute-by-minute price of electricity is set by the most recent, and most expensive, plant dispatched into the grid. Since the inception of the transmission organizations, the last form of generation into the grid has always been natural gas. Because gas generated electricity is expensive, any form of generation (such as generation from coal, nuclear or wind) with a marginal cost below that of gas, is profitable for the unit owner. The effect of the mercury rule is related to the extent that the rule changes the economics of these resources and to the extent that power generated by coal-fired EGUs remains economical for resale in an interstate system.

IPM shows a reduction in electricity generation from Illinois' coal-fired power plants as a result of the proposed mercury rule. The loss in generation lowers exports to neighboring regions. Some of this lost generation is due to the predicted retirement of the six units previously identified. The remaining loss in coal-generated electricity may be due to lost competitive pricing advantage due to additional costs associated with the proposed mercury rule. IPM shows that average production costs increase two to four percent across the study period. It should be noted that regardless of the potential loss in electricity generation from coal, the model foresees that Illinois will remain a net exporter of electricity, albeit at lower levels than if no mercury rule were implemented.

### 10.14 Summary of Costs to Industry and Consumers vs. Public Health Benefits/Costs

Table 10.3 provides a summary of estimated costs to the power sector and Illinois consumers taken from aforementioned studies by Staudt and IPM modeling performed by

ICF. The table also illustrates the cost benefits of mercury pollution control taken from the aforementioned studies by USEPA, Harvard/NESCAUM, Trasande et al., and Rice.

**Table 10.3 Summary of Cost-Benefit Analyses**

| Study | Highlights |
|---|---|
| **IPM Model**<br>Proposed Illinois Mercury Rule vs. CAMR | ▪ Proposed Illinois mercury rule results in increased retail electricity prices – 0.05 cents/kWh in 2009, 0.15 cents/kWh in 2015, 0.10 cents/kWh in 2018<br>▪ Less than $1.50 increase per month for residential consumers<br>▪ Average production cost increase 2-3%<br>▪ Additional compliance cost to power sector in 2009 - $68 million or $0.80 per MWh |
| **Staudt**<br>Proposed Illinois Mercury Rule vs. CAMR | ▪ Additional compliance to power sector - $29 million annually from 2010 - 2017<br>▪ Negligible difference in compliance cost in 2018 and after between CAMR and proposed Illinois mercury rule<br>▪ Greatest portion of increased costs is associated with additional sorbent usage |
| | |
| **USEPA**<br>Health benefits of mercury control | ▪ $10.4 to 46.8 million annually in benefits from neurological effects in the U.S. from CAIR/CAMR |
| **Harvard/NESCAUM**<br>Health benefits of mercury control | ▪ $75 to $194 million annually (after 26 ton cap in 2010) nationally in benefits from neurological effects in the U.S. from CAIR/CAMR<br>▪ $119 to 288 million annually (after 15 ton cap in 2018) nationally in benefits from neurological effects in the U.S. from CAIR/CAMR |
| **Trasande et al.**<br>Cost to society of mercury pollution from U.S. power plants | ▪ $0.4 to $15.8 billion (due to U.S. anthropogenic sources) in costs to society from neurological effects in the U.S. from CAIR/CAMR<br>▪ $0.1 to $6.5 billion (due to U.S. coal-fired power plants) in costs to society from neurological effects in the U.S. from CAIR/CAMR |
| **Rice**<br>Cost to society of mercury pollution from U.S. power plants | ▪ $1.3 billion annual cost to society attributed to U.S. power plants due to loss in IQ<br>▪ $289 million annual cost to society attributed to U.S. power plants due to mental retardation<br>▪ Effects of cognitive deficits in adults, accelerated aging, and impairment of the elderly to live independently due to methylmercury exposure, remain unmonetized. Cost to society of mercury exposure may be substantially underestimated. |

Some discrepancies in costs associated with the proposed Illinois mercury rule and CAMR can be attributed to differences in assumptions concerning the state of the art in mercury control technology. USEPA studies make the assumption that reliable and cost effective mercury specific control technology will not be available until 2018. Studies by

Staudt and ICF reflect more recent knowledge of mercury control technology, as well as other updated information on operations at Illinois coal-fired power plants.

Some discrepancies in estimates of human health benefits associated with mercury pollution are due to differences in research goals. The USEPA and Harvard/NESCAUM studies focused on monetized health benefits of mercury emission reductions due to regulation of the power sector. The studies conducted by Rice and Trasande et al. focus on the cost to society of mercury pollution from U.S. power plants. In both of these studies it is suggested that the societal burden due to mercury pollution may be underestimated. In addition, the studies measuring health benefits of mercury control do not take into account evidence from Florida and Massachusetts suggesting that local reductions in mercury emissions can substantially reduce mercury contamination in fish. Such local reductions could magnify the local economic benefit of improved health impacts in Illinois.

It should also be noted that a review by the Office of Inspector General of the USEPA found that the studies conducted by the USEPA in developing CAMR did not meet the requirements of several executive orders and were inconsistent with accepted standards in conducting thorough cost-benefit analysis. It is also noted by the Office of Inspector General that CAMR was finalized before a comprehensive children's health analysis was completed.

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