



Mercury Emissions from Coal-fired Power Plants

Public Health and Welfare Finding Pursuant to
Section 285.27(2)(b), Wisconsin Statutes

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This document is available on-line at <http://dnr.wi.gov/air/toxics/mercury/rule.htm>.

Mercury Finding Pursuant to Section 285.27 (2)(b), Wisconsin Statutes

Finding

A revised mercury emission standard for coal-fired electrical generating units is necessary to provide adequate protection of public health and welfare from the mercury risk in Wisconsin.

Overview

The Wisconsin Department of Natural Resources proposes to adopt administrative rules for a revised emission standard for mercury. In the absence of a federal standard promulgated under section 112 of the Clean Air Act, the Department may promulgate a standard if it finds that a standard is needed to provide adequate protection of public health and welfare. This document contains the written documentation to support the finding that a revised standard for mercury is needed for coal-fired electric generating units (EGUs), as required under Wis. Stats. 285.27(2)(b) (*Appendix A*).

This document includes the following four sections that correspond to the elements for which written documentation supporting the finding are required:

- Section 1 - Identify sources of mercury and populations potentially at risk.
- Section 2 - Assess whether exposures to mercury are above a level of concern.
- Section 3 - Evaluate options to control risks from mercury exposures.
- Section 4 - Compare mercury emission standards proposed with those from neighboring states.

On May 18, 2005, the federal Clean Air Mercury Rule (CAMR) requiring emission reductions from coal-fired EGUs was promulgated by the United States Environmental Protection Agency (EPA) under section 111 of the Clean Air Act. The purpose of regulations developed under section 111 is to ensure that emission standards for significant sources reflect advancements in air pollution control technology. Therefore, section 111 emission standards are not directed specifically at public health protection. On the other hand, regulations developed under section 112 are focused on protecting public health and welfare.

On February 8, 2008, the Washington D.C. Court of Appeals vacated the CAMR as well as EPA's removal of coal-fired EGUs from the list of source categories under section 112, the Hazardous Air Pollutant section, of the Clean Air Act (*State of NJ v. EPA*, D.C. Ct. App. No. 05-1097). In 2005, the EPA had removed coal-fired EGUs from the section 112 source category list in order to regulate the emissions through a cap and trade program under section 111. The Court found that the EPA's action was "unlawful" and therefore coal-fired EGUs cannot be regulated under section 111 unless EPA makes the finding that "emissions from no source in the category or subcategory concerned ... exceed a level which is adequate to protect public health with an ample margin of safety and no adverse environmental effect will result from emissions from any source." This

decision vacates the CAMR. It is not clear, when, and in what manner, EPA will address mercury emissions from coal-fired EGUs. The EPA or other parties that intervened in the case may petition for reconsideration or rehearing. The deadline for petitions is March 24, 2008.

Thus, to date, federal mercury rules have not been promulgated under section 111 or 112 of the Clean Air Act. If EPA promulgates emission limitations for hazardous air pollutants pursuant to section 112, Wisconsin is required to promulgate similar emission limitations for hazardous air pollutants, as required under Wis. Stat. 285.27(2)(a). In the absence of a federal standard promulgated under section 112, the Department may promulgate a standard if it finds that a standard is needed to provide adequate protection of public health and welfare, as required under Wis. Stat. 285.27(2)(b).

The Department is proposing a revision to the mercury emission requirements affecting coal-fired EGUs in the current state mercury rule, Chapter NR 446, Wis. Adm. Code. This finding supports a revision to the state's current mercury emission standard that provides protection of public health and welfare.

Background

Mercury moves through the environment contaminating aquatic food webs and posing a health threat to humans and wildlife that consume fish. Mercury from natural and man-made sources is released to the atmosphere, where it is transported and deposited in terrestrial and aquatic ecosystems. Bacteria in lakes and waterways convert mercury to a more toxic form, methylmercury, which bioaccumulates and biomagnifies in fish. Bioaccumulation is the build-up of a substance in an organism from the surrounding air or water, or through the consumption of contaminated food. Biomagnification means that concentrations of a substance increase at successively higher levels of the food chain. Methylmercury concentrations in fish may be 10 million times higher than those found in water. Exposure to methylmercury from eating sufficient quantities of contaminated fish is known to affect human health and development and is associated with a decline in wildlife populations.

Mercury Contamination in Wisconsin's Environment

The Department's earliest examination of mercury contamination began in 1970. This included fish sampling in the Wisconsin River where known sources of mercury were a concern. Department studies, in 1972, examined mercury concentrations in upland game such as white-tailed deer and cottontail rabbits. These studies found that mercury concentrations were very low in these mammals, which were all herbivores. A 1978 study found much higher mercury levels in fish-eating mammals, such as mink, as did a 1976 through 1979 study of fish-eating birds, such as eagles and loons. Significantly, these early studies showed a direct relationship between mercury concentrations found in predators and their prey. The Department continued to expand monitoring in the 1980s to include more lakes as a result of reports of elevated mercury in fish from lakes remote from known sources of mercury. Wisconsin began to issue mercury-based

consumption advisories in 1985 after the department identified elevated mercury levels in sport fish harvested from several northern lakes.

In 2001, the state changed its mercury advice to people on how they can safely eat fish caught from Wisconsin's inland waters contaminated with mercury. The changes reflected the latest scientific findings and the recommendation of the Wisconsin Department of Health and Family Services to use values that better protect human health. As a result, all inland waters in Wisconsin have the same general consumption advice on how many meals of certain species people can safely eat to keep their mercury exposure at or below acceptable risk levels. Consumption frequency recommendations provided for sensitive populations including pregnant women and young children, age 15 and younger as well as for adult men and older women are intended to prevent over-exposure to methylmercury and are calculated using the mercury levels found in Wisconsin fish. In addition, more stringent advice is provided for species from lakes where higher concentrations of mercury have been documented. In 2007, 93 lakes required advice more stringent than the general advice.

Adequacy of the Federal Clean Air Mercury Rule¹

Coal-fired EGUs are the largest human-caused source of mercury air emissions in the United States, accounting for over 40 percent of all domestic human-caused mercury emissions. EPA has estimated that about one quarter of U.S. emissions from coal-fired EGUs are deposited within the contiguous U.S. and the remainder enters the global cycle. Coal-fired EGUs in Wisconsin account for approximately 60% of our stationary source mercury emissions according to 2005 air emission inventory data.

EPA previously made a determination in December 2000 that it "was appropriate and necessary" to regulate mercury emissions from coal-fired EGUs through the hazardous air pollutant provisions in section 112 of the Clean Air Act. This determination was based upon a study mandated by section 112(n)(1)(A) of the Clean Air Act, as well as subsequent information and consideration of alternative feasible control strategies. It found that mercury emissions from EGUs, which are the largest domestic source of mercury emissions, present significant hazards to public health and the environment.

In 2005, EPA, in parallel with the promulgation of the CAMR, developed regulations that revised their December 2000 finding and removed EGUs from the list of source categories that need to be addressed under section 112. The rejection by EPA of their December 2000 determination and promulgation of the CAMR under section 111 of the Clean Air Act was widely criticized by state and local air quality agencies and nongovernmental organizations as inappropriate and inadequate in terms of protecting public health and welfare. The regulation of coal-fired EGUs under section 111 allowed the EPA to use a cap and trade program. In contrast, section 112 requires unit-by-unit controls on a shorter timeframe.

¹ This rule was promulgated by EPA but has since been vacated by a federal court. However, the rule was in place as Wisconsin prepared its draft mercury rule revisions and it provides important context to Wisconsin's rulemaking.

A number of states have proceeded to address public health concerns by establishing laws and regulations that achieve more mercury reductions sooner than the CAMR would have achieved for coal-fired EGUs in their jurisdiction. Most of these states also rejected the national trading program EPA developed as a compliance option for state's to meet the CAMR. According to the Congressional Research Service, as of July 2006, 13 states have programs that require reductions in mercury emissions of 80% to 90% with effective dates from 2007, at the earliest, to 2015.

Proposed Revisions to the Current State Mercury Rule - April 2007

At their April 2007, meeting the Natural Resources Board authorized public hearings on revisions to the current state mercury rule in response to three separate but related actions. This included promulgation of the federal CAMR in May 2005, a directive from Governor Doyle in August 2006 to further reduce mercury emissions, and a January 2007 citizen petition requesting revisions to Chapter NR 446.

The CAMR, now vacated, required the reduction of mercury emissions from new and existing coal-fired EGUs through a cap on mercury emissions expressed as an annual state emission budget that includes two phases of reductions. The initial phase was to begin in 2010 and continue until 2017. The second phase was to begin in 2018 and continue indefinitely. Wisconsin's budget during the first phase (2010 to 2017) was 0.890 tons (1,780 pounds) of mercury per year and declined to 0.351 tons (702 pounds) of mercury per year in 2018 and every year thereafter. State mercury budgets were permanent caps regardless of growth in the electrical sector. A national mercury emissions trading program was developed by EPA as an option for states to meet their CAMR state mercury emission budget.

Governor Doyle's directive issued on August 25, 2006, requires the Department to develop a rule achieving a 90% reduction of mercury emissions from coal-fired power plants. The Citizen Petition was submitted on January 22, 2007, to the Department and Natural Resources Board under provisions in s. 227.11(2)(a) and 227.12(1) and (2), Wis. Stats., and NR 2.05 Wis. Adm. Code. The petition requested the Department and Board to conduct rulemaking proceedings to revise and adopt rules that require a 90% to 95% reduction in of mercury to the air from coal-fired EGUs in the state by January 1, 2012.

The Department is proceeding with this rulemaking to address Governor Doyle's directive and to respond to the January 2007 citizen petition. This public health and welfare finding supports development of a mercury control standard which addresses the Governor's Directive and the citizen petition.

Finding Summary

The following summary statements are the key conclusions from the written documentation that supports the finding that a revised mercury emission standard for

coal-fired EGUs is necessary to protect public health and welfare from mercury exposure.

1. Health experts worldwide have identified the reduction of mercury exposures as a major public health goal.
2. The Wisconsin Department of Health and Family Services, federal governmental organizations, and international governments and institutions have identified women of child-bearing age, infants and children as the populations at greatest risk from elevated mercury exposure.
3. Recent research has identified mercury effects on the immune system and a potential role of mercury exposure in elevating the risks of heart disease and heart attacks in adults.
4. In the United States, the majority of mercury exposure to people and wildlife occurs from eating mercury contaminated fish. Increased fish consumption is related to an increase of mercury in the body, usually measured in the blood or hair.
5. Wisconsin has issued mercury-based sport-fish consumption advisories for people of all ages since 1985.
6. Nationally, about 5-10% of women of childbearing age have elevated mercury levels in their blood that poses a potential risk to unborn children. These risks include developmental effects such as lower performance on language, attention and memory tests and adverse effects in vision and motor functions. Two Wisconsin studies have found elevated mercury levels in approximately 6% of women of childbearing age.
7. A 2004 survey of hair mercury concentrations in Wisconsin residents showed that 29% of men and 13% of women had mercury levels above the Wisconsin and National guideline value of 1 ppm. The United States Environmental Protection Agency has determined that hair mercury concentrations in excess of 1 ppm are a level of concern for adverse effects.
8. A survey conducted by the Wisconsin Department of Health and Family Services in 1999 found that more than 90% of Wisconsin women between the ages of 18 to 45 include fish in their diets and that approximately one-third of them consume sport-caught fish.
9. It is estimated that approximately 437,000 men and women in Wisconsin are exposed to mercury above the safe level established by the United States Environmental Protection Agency.
10. Fish eating birds and mammals in Wisconsin are at risk of adverse health effects from mercury contamination and laboratory studies demonstrate that mercury levels typically found in the environment can cause negative impacts on fish reproductive success.
11. Wisconsin based studies have found that reduced atmospheric mercury deposition results in lower levels of fish contamination in sensitive lakes. Fish mercury levels in Little Rock Lake, Vilas County, decreased by 30% between 1994 and 2000, coinciding with a similar decrease in atmospheric mercury loading over the same time period. The authors attributed the change in mercury loading to decreased emissions of mercury from commercial and industrial sources in the region.

12. This pattern of lowered mercury deposition rates has also been observed in Minnesota. A study of 176 lakes in Minnesota found decreasing trends in mercury deposition and during that time, mercury levels in fish dropped in 87 lakes, stayed the same in 45 lakes and increased in 44 lakes.
13. Evidence from Europe, the state of Washington, the northeastern United States and southeastern Canada shows that if mercury emissions are reduced, there can be a significant lowering of mercury levels in fish and wildlife.
14. Studies where isotopes of mercury have been added to research plots to track where the mercury ends up, have generally found that mercury and methylmercury concentrations in sediments, water, plant and animal life were all linearly related to this added mercury deposition. This suggests that increases (and decreases) in mercury will affect concentrations in sediments, water, plant and animal life as well.
15. Since several studies in the U.S., Canada and Europe have shown that local and regional reductions in mercury emissions led to lower rates of atmospheric mercury deposition and lower concentrations of mercury in air, rain, water and fish, it is reasonable to conclude that reducing mercury sources in Wisconsin will have positive effects on the environment and public health.
16. The State of Michigan estimates that about half of the mercury emitted from coal-fired power plants is readily deposited and a recent study has identified atmospheric reactions enhancing the tendency for local and regional mercury deposition.
17. The most significant stationary source category of mercury emissions in Wisconsin is coal-fired EGUs currently accounting for 62.5% of stationary source mercury emissions. After a planned conversion in 2009 to a mercury free chlor-alkali production process at ERCO Worldwide, coal-fired EGUs will continue to be the largest stationary source of mercury air emissions in Wisconsin but the proportional share will increase to 86% of total mercury air emissions.
18. Emission control technologies are commercially available to reduce mercury releases from the types of coal-fired EGUs operating in Wisconsin. Additional technologies, suitable for commercial application, will be available within the next seven years.
19. Air pollution control technology used to reduce particulate matter, nitrogen oxides and sulfur dioxide from coal-fired EGUs can also be effective at reducing mercury emissions. However, since their effectiveness varies by coal types, between units and within units over time, mercury specific control techniques are necessary to achieve consistent and effective mercury removal particularly for subbituminous coal-fired EGUs.
20. With the development of mercury specific technologies including Toxecon®, halogenated activated carbons, and oxidizing chemicals a 90% or greater mercury removal efficiency is feasible for bituminous and subbituminous coal-fired EGUs in Wisconsin.
21. The cost of fly ash disposal is still an issue that must be weighed in the selection of a mercury control approach for existing EGUs.
22. The costs of commercially available and emerging mercury control technologies for coal-fired EGUs are reasonable in comparison to the costs to control conventional pollutants, including particulate matter, nitrogen oxides and sulfur dioxide.

23. Twenty-two states have or are proposing requirements that achieve more mercury emission reductions than the vacated federal CAMR.
24. Among the states in EPA's Region 5, Illinois, Michigan and Minnesota are proposing or have adopted requirements more stringent than Wisconsin's current rule affecting coal-fired EGUs.
25. In recognition of the advancements that have occurred in mercury control technology since the development of the current state mercury rule in 2003, including improved effectiveness and lower cost, it is appropriate to establish a revised mercury rule that will achieve greater mercury emission reductions from coal-fired EGUs.
26. Proposed revisions to the state mercury rule in chapter NR 446, Wis. Adm. Code, adopt a mercury emission standard that is comparable to the mercury emission standards for coal-fired EGUs in neighboring states.
27. Wisconsin, like Illinois, Michigan and Minnesota is requiring large coal-fired EGUs to achieve a 90% reduction based on mercury in coal combusted. Dates by which compliance with this mercury emission standard is required varies from 2009 to 2021. In part, this variation can be attributed to the availability of multipollutant reduction options that extends the mercury reduction compliance date in exchange for reductions in sulfur dioxide and nitrogen oxide.
28. Substantial reductions in sulfur dioxide and nitrogen oxide emissions would, however, be achieved by 2015 under the multipollutant option included in the proposed revisions. These reductions will help to lower mercury contamination levels in fish due to the link between acid rain and methylmercury production as demonstrated by experimental studies on Little Rock Lake, Vilas County. These reductions will also address other critical air quality concerns including fine particles, haze, and ground level ozone.
29. Wisconsin, like Illinois and Michigan, will include mercury emission standards for new coal-fired EGUs or power plants.
30. Developing a revised emission standard for coal-fired EGUs to protect public health under the provisions of s. 285.27(2)(b) Wis. Stats. is the most appropriate option to achieve significant mercury emission reductions from stationary sources since coal-fired EGUs are the stationary source category that accounts for the majority of mercury emissions in Wisconsin.

Section 1 - Identify sources of mercury and populations potentially at risk (“A public health risk assessment that characterizes the types of stationary sources in this state that are known to emit the hazardous air contaminant and the population groups that are potentially at risk from the emissions.” - s. 285.27(2)(b)1., Wis. Stats.)

Stationary Sources in Wisconsin that are Known to Emit Mercury

Wisconsin air emission inventory data indicates that three major types of stationary sources are responsible for mercury air emissions in the state:

1. Coal-fired electrical generating units.
2. ERCO Worldwide chlor-alkali facility in Port Edwards.
3. Industrial coal-fired power boilers.

According to 2005 air emission inventory data, a total of 4,140 pounds of mercury was released into the environment from stationary air pollution sources. Of this total, 2,586 pounds (62.5%) came from coal-fired electrical generating units and 1,139 pounds (27.5%) from the chlor-alkali facility in Port Edwards, Wisconsin. Another 195 pounds (4.7%) came from coal-fired power boilers located at industrial facilities in the state.

Wisconsin’s sole chlor-alkali facility, ERCO Worldwide, has announced that it will undergo modifications to eliminate its mercury cell technology by the end of 2009. The proportionate share of mercury emissions from coal-fired electrical generating units in Wisconsin will significantly increase (percent from this source will go from 62.5% to 86% of state emissions) and they will remain the largest mercury stationary source category in Wisconsin (**Table 1.1**).

Table 1-1 Wisconsin Stationary Source Mercury Emission Sources

| Stationary Source Category | 2005 Mercury Emissions - Pounds | Number of Processes** | Pounds Mercury Emissions per Process | Contribution of Mercury Emissions Statewide | |
|---|---------------------------------|-----------------------|--------------------------------------|---|------------------|
| | | | | w/ Chlor-alkali | w/o Chlor-alkali |
| ERCO Chlor-alkali Production | 1,139 | 1 | 1,139 | 27.5% | |
| Solid Fuel-fired Electrical Generating Units* | 2,586 | 62 | 42 | 62.5% | 86.2% |
| Industrial, Institutional and Commercial Solid Fuel Boilers | 195 | 74 | 2.6 | 4.7% | 6.5% |
| Sludge Drying and Combustion | 95 | 5 | 18.9 | 2.3% | 3.2% |
| Foundry | 55 | 5 | 10.9 | 1.3% | 1.8% |

| Stationary Source Category | 2005 Mercury Emissions - Pounds | Number of Processes** | Pounds Mercury Emissions per Process | Contribution of Mercury Emissions Statewide | |
|--------------------------------|---------------------------------|-----------------------|--------------------------------------|---|------------------|
| | | | | w/ Chlor-alkali | w/o Chlor-alkali |
| Waste Incineration | 34 | 5 | 6.7 | 0.8% | 1.1% |
| Natural Gas and Oil Combustion | 18.5 | 553 | 0 | 0.4% | 0.6% |
| Remaining Categories | 18.3 | 13 | 1.4 | 0.4% | 0.6% |
| | 4,140 | 718 | 5.8 | | |

Wisconsin DNR Air Emissions Inventory - 2005, Bureau of Air Management.

*Solid fuel EGU boilers are primarily coal-fired but other reported fuels include coke, tires, biomass, and paper pellets.

**Firing of different fuels is reported as separate processes for the same unit therefore there may be multiple reported processes for a single emission unit (e.g. a boiler burning coal and coke have two reported processes in the air emission inventory). The one exception is the ERCO chlor-alkali production which has nine separate reported processes but for purposes of this analysis they are considered one process.

Population Groups that are Potentially at Risk from Mercury Exposure

Women, infants and children are especially susceptible to the neurological effects of mercury based on research regarding mercury health effects (*Knobeloch et al., 2006; EPA, 2007*). For people as well as for fish eating birds and mammals, the majority of mercury exposure comes from fish consumption. “Wisconsin has issued mercury-based sport-fish consumption advice to people of all ages since 1985” (*Knobeloch et al., 2006*). *In utero* exposures to methylmercury have been linked to developmental effects such as lower performance on language, attention and memory tests and have also been associated with adverse effects in vision and motor functions (*Mergler et al., 2007*).

In addition, mercury has effects on the immune system. There is recent evidence that suggests that exposure to methylmercury at concentrations currently being measured may result in an elevated risk of cardiovascular disease and heart attacks (in men and possibly in women as well) to a significant fraction of the population (*Mergler et al., 2007*).

Section 2 - Assess whether exposures to mercury are above a level of concern (“An analysis showing that members of population groups are subjected to levels of the hazardous air contaminant that are above recognized environmental health standards or will be subjected to those levels if the department fails to promulgate the proposed emission standard for the hazardous air contaminant.” - s. 285.27(2)(b)2., Wis. Stats.)

Population Groups Exposed Mercury Contamination in Wisconsin above Recognized Health Standards

The EPA’s reference dose is the value chosen to represent the best estimate of a “safe” level of exposure to methylmercury. The EPA reference dose of 0.1 ug/kg/day corresponds to a blood mercury level of 5.8 ug/L (ppb) and a hair mercury level of approximately 1 ug/g (ppm) (**Table 2-1**). The reference dose is based on human studies and is intended to protect against the neurodevelopmental effects of prenatal exposure as well as potential effects of this toxin on the cardiovascular system and aging nervous system (*Knobeloch et al., 2006; EPA, 2007; Mergler et al., 2007*).

Table 2-1 EPA Levels of Concern in Humans – Equivalent levels of concern expressed as daily intake, blood levels and concentration in hair (Knobeloch et al. 2006).

| Micrograms per kilogram per day (ug/kg/day) | Blood Concentration in micrograms per liter of blood (ug/L) = parts per billion | Hair Concentration in micrograms per gram (ug/g) = parts per million |
|---|---|--|
| 0.1 | 5.8 | 1 |

The EPA’s reference dose was evaluated in 2000 by the National Research Council and by the World Health Organization in 2003. Both organizations endorsed the EPA’s reference dose as the appropriate methylmercury exposure standard (*US National Research Council 2000; WHO-JEFCA 2003*). The State of Wisconsin Department of Health and Family Services has accepted the EPA reference dose as the best available health benchmark and currently uses it to develop Wisconsin’s fish consumption advisories.

Health experts worldwide have identified the reduction of mercury exposures as a major public health goal. At the Eighth International Conference on Mercury as a Global Pollutant, the panel on “Health Risks and Toxicological Effects of Methylmercury” made the following recommendation:

“[T]o preserve human health, all efforts need to be made to reduce and eliminate sources of exposure, through regulation and dissemination of information”(Mergler et al., 2007).

A survey of hair mercury levels in 2,031 Wisconsin residents showed that 29% of men and 13% of women had mercury levels above EPA’s established level of concern for mercury of 1 ppm (*Knobeloch et al., 2007*). It is estimated that approximately 437,000

men and women in Wisconsin are exposed to mercury above the safe level established by the United States Environmental Protection Agency (*Knobeloch, 2005*). Because of the increased popularity of fish as a source of dietary protein, a significant percentage of the U.S. population may be at risk of methylmercury-induced health problems. A case report series authored by Knobeloch et al., 2006, summarizes information for several Wisconsin residents who were found to have high blood or hair mercury levels after they ate repeated meals of contaminated commercial or locally-caught fish. Some of these individuals described vague symptoms such as mental confusion, sleep difficulty, balance problems or visual disturbances that improved after their mercury levels returned to normal.

Nationally, about 5-10% of women of childbearing age have elevated mercury levels in their blood that poses a potential risk to unborn children (*McDowell et al., 2004*). A separate study of Wisconsin women estimated that about 6% of women of childbearing age had elevated mercury levels (*Knobeloch et al., 2005*). A survey conducted by the Wisconsin Department of Health and Family Services in 1999 found that more than 90% of Wisconsin women between the ages 18 and 45 include fish in their diets and that approximately one-third of them consume sport-caught fish (*Knobeloch et. al., 2005*).

Symptoms of clinical toxicity such as vision problems, hypertension, and tremors have been associated with blood mercury levels above 50 ug/L (*Agency for Toxic Substances and Disease Registries 1999*). There have been a few cases in Wisconsin where fish consumption has been associated with blood concentrations in the range of 50 ug/L (*Knobeloch et. al., 2006*).

Mercury Contamination in Wisconsin Wildlife Populations

Due to a combination of mercury loading and ecological sensitivity many Wisconsin lakes, especially in northern Wisconsin, have elevated levels of mercury in fish. Fish-eating birds and mammals have exposures in the same range that experimental studies have shown to cause behavioral, neurological and reproductive system effects (*Scheuhammer et al., 2007*).

Large regions of Wisconsin are considered to be highly sensitive to atmospheric mercury deposition. Lakes in sensitive regions typically share the following characteristics:

- Low alkalinity, low pH lakes that are not drainage lakes (i.e., they do not have a significant river flow into and out of the lake).
- Wetlands, land uses and water level fluctuations that enhance the ability of deposited mercury to be converted into methylmercury.
- Food chains with predatory fish, such as walleye, musky and largemouth bass, that bioaccumulate the methylmercury to high levels (*Munthe et al., 2007; Watras et al., 2006; Meyer, 2006; Rasmussen et al., 2007*).

Loon diets that contain fish with mercury levels above 0.2 parts per million have been shown to have adverse effects such as reduced reproductive success (*Evers et al., 2007; Scheuhammer et al., 2007; Burgess & Meyer, 2008*). Wisconsin loons nesting on acidic lakes (pH < 6.3), with higher methylmercury concentrations in fish, showed reduced reproductive success compared to loons elsewhere in Wisconsin (*Meyer et al., 1995; Meyer et al., 1998*). Loon chicks have been shown to be particularly sensitive to methylmercury exposures such that fish mercury levels above 0.4 ppm are a concern (*Scheuhammer et al., 2007*). In addition to reproductive toxicity, mercury is also suspected of affecting bird survival due to immune suppression (*Scheuhammer et al., 2007; Kenow et al., 2007*). Studies of loons suggest that exposure to fish with a methylmercury concentration above 0.2 ppm may be responsible for reduced reproduction and survival rates. Fish in many Wisconsin lakes are above 0.2 ppm (*Evers et al., 2007*). Population modeling suggests that loon populations will benefit from reductions in mercury loading to lakes where they feed and nest (*Meyer, 2006*). It is likely that other fish-eating species will also benefit.

Mink and otter, two piscivorous (fish eating) mammals, have been identified as susceptible to mercury toxicity. It is probable that current environmental exposures are sufficiently high to have neurological and reproductive effects (*Scheuhammer et al., 2007*).

Wild piscivorous fish may also be at risk from elevated methylmercury exposure and toxicity as well. These types of fish include sport fish like musky and walleye. Effects of concern at environmentally relevant exposure levels (less than 1 ppm) include impairment of fish behavior, gonadal development, production of sex hormones and reproduction (*Scheuhammer et al., 2007*). A study of Wisconsin perch found that methylmercury levels in the eggs were within the range of mercury effects levels derived from laboratory toxicity studies (*Hammerschmidt, 1999*), which suggests the potential for reproductive effects occurring in Wisconsin fish populations.

Relationship between Mercury Emissions and Mercury Contamination

Several lines of evidence show that there is a positive relationship between mercury emissions and mercury contamination in Wisconsin. Evidence further indicates that a measurable response to changes in mercury deposition can occur over time-scales of less than one year.

Sediment cores from lakes in Minnesota and Wisconsin show that atmospheric mercury deposition increased by roughly three-fold with increasing industrial activity throughout most of the 20th century (*Swain and Engstrom, 1992; Fitzgerald et al., 1998*). After 1990, declines in mercury deposition coincided with a regional decrease in the industrial and commercial use of mercury and reduced smelting activity (*Engstrom and Swain, 1998; Watras et al., 2000*). Along with declining mercury deposition, there have been contemporaneous reductions in the concentration of mercury in water and fish (*Hrabik and Watras, 2002; MPCA, 2006; Rasmussen et al., 2007; Watras and Morrison, 2008*).

Studies on Little Rock Lake in Vilas County showed that when atmospheric mercury deposition to the lake declined by roughly 40% between 1994 and 2000, there were similarly large declines for mercury in water and fish (*Hrabik and Watras, 2002*). These findings implied that the bioaccumulation of mercury depended more on the deposition of “new” mercury than on the remobilization of “old” historically-deposited mercury stored in sediments and watershed soils. Similar findings have been reported for Devils Lake in Forest County (*Watras and Morrison, 2008*).

The findings for Little Rock Lake and Devils Lake are supported by two field studies that document reductions in fish mercury across northern Wisconsin. Rasmussen et al. (2007) reported that mercury in walleye have decreased on average by 5% per decade since 1982. Similar findings were reported by Madsen and Stern (2007) using an independent set of Wisconsin fish data compiled by native tribes.

Field experiments in Canada support the Wisconsin studies. In these experiments mercury isotopes were added to lake water to track its movement into the aquatic food chain. The experiments showed that added mercury moved rapidly into lower levels of the food chain and then were rapidly transferred to higher trophic levels, including fish (*Orihel et al., 2006; Harris et al., 2007*). Together with the Wisconsin studies, these experiments confirm that increases and decreases in the deposition of “new” mercury can have substantial and rapid effects on food chain contamination.

Although mercury is a global problem, it has local and regional dimensions. Field studies in Washington state, Ohio, Sweden and Germany show that mercury emissions influence mercury deposition near sources (0 – 500 miles). Mercury deposition near Seattle, Washington declined significantly after mercury emissions from local waste incinerators were reduced (*Prestbo et al., 2006*). In southern Sweden, mercury concentrations in air, rain and fish declined after the reduction of large mercury emission sources in eastern Germany during the early 1990s (*Johansson et al., 2001; Munthe et al., 1995; 2001*). In eastern Ohio, the major contributor to mercury in rain was found to be local and regional coal combustion (*Keeler et al., 2006*).

Due to the influence of certain co-factors, the ecological response to mercury deposition can vary from lake-to-lake and from time-to-time. Sulfate reducing bacteria are known to mediate the conversion of atmospherically-deposited mercury to methylmercury, so factors that affect the abundance and activity of these bacteria affect mercury bioaccumulation. For example, when sulfate was added experimentally to Little Rock Lake, methylmercury production and fish contamination increased substantially (*Watras et al., 2006*). After the experiment when concentrations of sulfate declined over time, methylmercury concentrations also declined. Thus, acid rain (which is enriched in sulfate) can exacerbate or ameliorate the effects of atmospheric mercury deposition (*Gilmour and Henry, 1991; Watras and Morrison, 2008*).

Fluctuating water levels also affect methylmercury production in lakes, which implies that climate change and land use are other important co-factors. When a small wetland in Canada was experimentally flooded, concentrations of methylmercury in water and

aquatic organisms increased due to the general stimulation of bacterial activity (*St. Louis et al., 2004*). Similarly, when water levels in Little Rock Lake declined during dry conditions from 1998-2007, concentrations of methylmercury increased due to drought-induced increases in sulfate (*Watras and Morrison, 2008*).

The chemical forms and reactions of mercury in the atmosphere determine the relationship between mercury emission and deposition. Atmospheric mercury consists of at least three different forms: particulate mercury, reactive gaseous mercury and zero-valent mercury (abbreviated as HgP, RGM and Hg⁰). Particulate mercury (HgP) and reactive gaseous mercury (RGM) are readily deposited via rainfall or adhere to the surface of leaves, branches, soil and water. Zero-valent mercury (Hg⁰) is less readily deposited; and, therefore, it constitutes most of the mercury in the air. The State of Michigan estimates that emissions from coal-fired power plants comprise 50% Hg⁰, 30% RGM and 20% HgP, which implies that about half of the emitted mercury is readily deposited (*Sills et al., 2007*). However, a recent study shows that Hg⁰ undergoes atmospheric reactions that convert it to RGM and/or HgP enhancing the tendency for local and regional deposition (*Lindberg et al., 2007*).

Based on the studies above and in consultation with Wisconsin-based as well as other national and international mercury research, it is reasonable to conclude that if mercury sources in Wisconsin reduce their mercury emissions, a local benefit will be seen in reduced mercury contamination in fish and wildlife. In addition, northern Wisconsin lakes in ecologically sensitive regions (e.g., low alkalinity, low pH) should show a fairly rapid response to decreased mercury deposition loadings, although there are many variables (such as sulfate deposition, land use, water table fluctuations, bioavailability, and the food chain within a given lake and watershed) that can affect the timing for observing any changes in contaminant levels in fish and wildlife (*Lindberg et al., 2007; Munthe et al., 2007; Watras et al., 2006; Evers et al., 2007; Watras et al., 2008*). Certainly the type of coal burned by a coal-fired power plant and the type of pollution control at the facility makes a difference in terms of the species of mercury emitted and where deposition occurs, but there are a large number of studies that conclude local and regional source controls are important to reduce local mercury deposition impacts.

Section 3 - Evaluate options to control risks from mercury exposures “An evaluation of options for managing the risks caused by the hazardous air contaminant considering risks, costs, economic impacts, feasibility, energy, safety, and other relevant factors, and a finding that the chosen compliance alternative reduces risks in the most cost-effective manner practicable.” - s. 285.27(2)(b)3., Wis. Stats.)

Stationary Sources of Mercury Emission

Because of their high proportionate share of mercury emissions it is appropriate to develop a revised emission standard to control of mercury emissions from coal-fired EGUs to manage mercury risks in Wisconsin. Section 1 identified coal-fired EGUs and the ERCO Worldwide chlor-alkali facility as the stationary sources that account for the majority of mercury air emissions in Wisconsin (**Table 1-1**). After conversion to a mercury-free chlor-alkali process is accomplished by ERCO Worldwide, coal-fired EGUs represent 86% of the 2005 mercury emissions. The remaining 14% of mercury emissions are emitted by many small combustion and industrial processes at numerous stationary sources.

In addition to the significant contribution of mercury emissions there are several additional critical considerations which support the adoption of a revised mercury emission standard for coal-fired electrical generating units.

- *Cost-effectiveness* - The amount of mercury emitted from each stationary source is significantly higher for EGUs than any other source category, with the exception of the ERCO chlor-alkali plant (**Table 1-1**). On average, EGUs emit 42 pounds per process. The source categories with the next highest emission intensities are sludge drying and combustion and foundry furnaces. Both source categories have annual emissions a fraction of EGUs and emission intensities less than half that of the EGU source category. Although other factors are relevant, the mercury emission intensity measured as pounds per process as well as the quantity of mercury emissions in comparison to other source categories are indicators of a cost-effective emission reduction opportunity. Other than coal-fired EGUs, there are no other major stationary source categories with as significant mercury reduction potential.
- *Mercury Reduction Potential in Other Source Categories* - Mercury emissions from several of the largest mercury emitting categories are already required to meet state or federal mercury emission standards requiring control technology to achieve a high level of mercury reductions. For example, municipal solid waste incinerators must meet a federal hazardous air pollutant standard requiring 80% to 90% mercury control efficiency. A federal hazardous air pollutant standard is under development for industrial, institutional and commercial solid fuel boilers.

Developing a revised emission standard for coal-fired EGUs to protect public health under the provisions of s. 285.27(2)(b) Wis. Stats. is the most appropriate option to achieve significant mercury emission reductions from stationary sources since coal-fired

EGUs are the stationary source category that accounts for the majority of mercury emissions in Wisconsin.

Mercury-containing Products

Mercury-containing products are another significant source of mercury discharge to Wisconsin's environment. Product disposal can result in mercury discharge to air, land and water. Eliminating mercury use in products and proper recycling are the approaches that can successfully address this source of mercury contamination. All significant discharges of mercury to the environment are important to address and a comprehensive state program includes actions that limit mercury emissions from stationary sources as well as proper management of mercury-containing products. It should be noted that the Department's authority under s. 285.27(2)(b) Wis. Stats. is confined to addressing stationary source mercury emissions.

Mercury Controls for Coal-fired Electrical Generating Units

Outlined below are the mercury control technologies that are or soon will become commercially available for coal-fired EGUs in Wisconsin. These control technologies applied alone or in combination can effectively achieve cost effective mercury emission reductions from coal-fired EGUs. Mercury control technology that effectively reduces mercury from coal-fired EGUs is commercially available now. Additional technologies, suitable for commercial application, will be available within the next seven years. In 2004, EPA announced that optimized multipollutant control (mercury, nitrogen oxides and sulfur dioxide) would be available after 2015 achieving 90% to 95% mercury control for all coal types. In 2006, EPA restated that it now believes that 90% to 95% control may be available for most, if not all, coal types between 2010 and 2015 (*USEPA, 2005*).

Coal-fired Electrical Generating Units in Wisconsin

In Wisconsin, electrical energy is primarily provided by coal combustion and the principal coal types used are subbituminous and bituminous. Other solid fuels, in small amounts, are also used for electrical generation including petroleum coke, tires, paper pellets and biomass. Subbituminous coal firing accounts for 84% of the solid fuel generating capacity. Large EGUs, greater than 150 megawatts (MW) account for 77% of our existing coal electrical generating capacity (**Table 3-1**).

Table 3-1 Coal-type, Capacity and Existing Air Pollution Control Systems

| Control System Configuration | Capacity in Megawatts | | |
|---|-----------------------|---------------|--------------|
| | Bituminous | Subbituminous | Total |
| <i>Electric Generating Units > 150 MW</i> | | | |
| Fabric Filter | | 338 | 338 |
| Electrostatic Precipitator - cold side | | 2,442 | 2,442 |
| Electrostatic Precipitator - hot side | | 558 | 558 |
| Electrostatic Precipitator + Fabric Filter | 349 | 366 | 715 |
| Electrostatic Precipitator + | | 1,234 | 1,234 |

| | | | |
|--|-------|-------|--------------|
| Selective Catalytic Reduction + Wet Flue Gas Desulfurization | | | |
| Electric Generating Units > 25 MW < 150 MW | | | |
| Fabric Filter | 345 | | 345 |
| Electrostatic Precipitator - cold side | 361 | 614 | 975 |
| Electrostatic Precipitator - hot side | | 219 | 219 |
| Mechanical Cyclone | 30 | | 30 |
| All Electric Generating Units | | | |
| > 150 MW | 349 | 4,938 | 5,287 |
| > 25 MW < 150 MW | 736 | 833 | 1,569 |
| Total | 1,085 | 5,771 | 6,856 |

| Unit Size in Megawatts | Percent by Coal Type | | |
|-----------------------------|----------------------|---------------|----------------------|
| | Bituminous | Subbituminous | Percent by Megawatts |
| > 150 MW | 7% | 93% | 77% |
| > 25 MW < 150 MW | 47% | 53% | 23% |
| Percent by Coal Type | 16% | 84% | |

The majority of large coal-fired EGUs in the state, greater than 150 MW, were originally fired with bituminous coal. However, these units have been converted to lower sulfur subbituminous coal to reduce acid deposition in the state. Currently, over 90% of the coal combusted by EGUs greater than 150 MW is subbituminous. EGUs less than 150 MW combust equal amounts of bituminous and subbituminous coal and are also the units primarily engaged in burning other solid fuels like petroleum coke, tires, paper pellets and biomass.

Coal-fired EGUs in the state are currently equipped with fabric filters or electrostatic precipitators to control particulate matter emissions. Several Wisconsin electric utilities are in the process of installing control technologies for sulfur dioxide and nitrogen oxides to address ozone, fine particulate and haze. Large EGUs are the center of this control technology effort because they are generally Wisconsin's newer units and will generate electricity for years into the future and therefore, appropriate for additional investments. For subbituminous coal-fired EGUs, a typical approach that is being considered is dry flue gas desulfurization (lime injection followed by a fabric filter). However, utilities in the state may elect or need to install a wet flue gas desulfurization on their subbituminous units. One state utility has this type of system in operation with a selective catalytic reduction system (SCR) to remove nitrogen oxides. Electric utilities in the entire eastern United States are undergoing these changes.

In Wisconsin, the focus is on mercury control technologies suitable for large EGUs burning subbituminous coal and compatible with the multipollutant control systems approaches under consideration.

Mercury Control Technology

Control technologies that are currently in use to limit nitrogen oxides, particulate matter and sulfur dioxide from coal-fired EGUs can also remove mercury. However the

effectiveness varies considerably between units and within a unit over time ranging from 0% to 99%, (*DOE, 2006*). Effectiveness also varies by coal type. Therefore, mercury specific control techniques are required to achieve consistent and effective mercury removal particularly for subbituminous coal-fired EGUs.

Summarized below are the three basic control strategies for reducing mercury. A growing number of technologies are becoming available under the mercury oxidation and absorption approaches that can achieve 90% control of mercury emission from bituminous and subbituminous coal-fired EGUs.

1. REDUCING MERCURY CONTENT OF COAL

Fuel substitution offers an effective but, limited approach to reducing mercury emissions. Subbituminous coal is known to contain less mercury than bituminous coal and petroleum coke contains considerably less mercury than any coal type. In addition, biomass and natural gas are fuels with insignificant mercury content. Coal washing and processing can lower mercury content. Coal washing can result in 30% mercury removal. A thermal treatment process is under development that is anticipated to remove 90% of the mercury in coal. Advanced methods of coal cleaning are being developed that show 60% to 80% mercury removal (*Chang, 2007*). One commercially marketed fuel, K-fuel, is subbituminous coal processed to improve combustion qualities and remove up to 70% of the mercury content (*Levin, 2007*).

2. MERCURY OXIDATION

Mercury in an oxidized form readily attaches to particulate matter in boiler exhaust gases and is captured by particulate air pollution control equipment. The amount of oxidized mercury in the exhaust gas of a coal-fired EGU is a function of the chlorine content of coal. In general, bituminous coals have higher chlorine content than subbituminous coals and there is considerable variability within coal types and considerable variability in chlorine contents in coal from the same mine.

Currently, the various combinations of coal types and particulate control equipment used by EGUs result in mercury removal that ranges from 0% to 99%, (*DOE, 2006*). A fabric filter system for control of particulates performs the best with mercury control efficiencies up to 99% for bituminous coal and 50% to 87% for subbituminous coal. Electrostatic precipitators for particulate control have shown similar effectiveness at mercury removal on bituminous coal however, for subbituminous coal mercury removal effectiveness is less with considerably more variability in performance. In general, the combination of subbituminous coal and electrostatic precipitators for particulate control achieve lower mercury control efficiencies than the combination of bituminous coal and fabric filter particulate control systems. As previously described, Wisconsin's large units (> 150 MW) are primarily fired by subbituminous coal with lower chlorine content.

Mercury in an oxidized form is also water soluble and therefore can be captured by a wet scrubber designed to reduce sulfur dioxide emissions. Capture of mercury by wet

scrubbers also varies considerably in mercury removal effectiveness ranging from 4 to 91% (DOE, 2006). The higher efficiencies are typical of the higher chlorine content bituminous coals while subbituminous coals are mainly at the lower range of effectiveness. For both coal types, higher removal efficiencies can be achieved by wet scrubbers that are preceded by Selective Catalytic Reduction (SCR) for nitrogen oxides control. Mercury oxidation is an additional benefit of this nitrogen oxides control technology.

The development of methods to enhance and consistently oxidize mercury is a high priority because the oxidized mercury can be removed using existing control equipment with minimal added cost. An additional advantage of oxidation is that it is an approach that does not impact fly ash like activated carbon sorbent technology. Improvements in mercury oxidation are occurring through two approaches; oxidizing catalyst beds and injection of halogen chemicals (e.g. chlorine). Both approaches are anticipated to improve mercury oxidation such that consistent 80% to 90% mercury removal efficiency is achieved for all coal types.

Specially formulated oxidizing catalysts are demonstrating 80 to 90% oxidation rates on all coal types (Chang, 2007). Strategies are being developed for injecting chemicals in a manner to augment the results of the oxidation catalyst to achieve higher, long term reductions (DOE, 2006). A catalyst vendor is reporting availability of a hybrid catalyst designed for nitrogen oxide reduction and capable of mercury oxidation of 95% for low chlorine coals (Gretta, 2007).

Oxidation techniques are currently capable of achieving 80% or greater mercury removal efficiency. The focus of development is now on achieving 90% mercury removal at specific coal-fired power plants. In general this is less of a challenge for fabric filter based systems which already achieve better results for low chlorine subbituminous coals. On the other hand, wet scrubber systems may require on-site testing to develop the specific strategy for a 90% mercury removal.

3. MERCURY ABSORPTION

Mercury absorption is a commercially available control technology and capable of achieving removal efficiencies of 90% or greater. According to the Institute for Clean Air Companies, 42 activated carbon injection systems for mercury control have been contracted for subbituminous coal-fired EGUs in the United States (ICAC, 2007). Of these contracts, 22 are for fabric filter systems. Three of these activated carbon injection systems are already in operation. Activated carbon injection ahead of electrostatic precipitators accounts for the remaining 20 contracts reported by ICAC. The pollution control industry believes that sorbent injection in combination with a fabric filter can readily achieve mercury removal rates in the 90% range with proper design. And injection ahead of an electrostatic precipitator can achieve 70% to 90% mercury control depending upon plant and control device characteristics (Campbell, 2007).

Absorption can be equally effective on oxidized and non-oxidized forms of mercury. Absorption is the physical capture of mercury with a compatible material. Capture of mercury already occurs in boiler exhaust gases by mercury absorption from unburned carbon created from coal combustion. Although activated carbon injection installations are occurring, improvement of mercury absorption approaches is desirable to address fly ash reuse concerns and increase mercury removal effectiveness for coal-fired EGUs in Wisconsin.

In the initial development of activated carbon as a sorbent for mercury control, high mercury removal efficiencies were achieved on bituminous coals but performance on subbituminous coals was mixed. For subbituminous coals 90% mercury removal efficiency with a fabric filter was achievable but activated carbon injection followed by an electrostatic precipitator was limited to 60% removal efficiency. High injection rates of activated carbon were required to obtain some of these results. From a multipollutant control perspective, fabric filters systems with lime injection for sulfur dioxide removal (dry flue gas desulfurization) lessened the effectiveness of the activated carbon at capturing mercury for subbituminous coals.

These early results indicated that high mercury removal efficiencies could only be achieved by using activated carbon injection with a fabric filter dedicated to particulate and mercury control. The development of Toxecon® evolved as a result. In this approach, a small compact fabric filter is installed specifically to remove mercury. WE-Energies has installed and operated a Toxecon® system at their Presque Isle facility in Michigan since February 2006. This installation is the initial long term evaluation of this mercury absorption approach. 90% mercury removal efficiency has been achieved. Valuable operating experience applicable to the use of Toxecon® on other coal-fired EGUs has also been gained (*Chang, 2007*).

Another viable mercury absorption approach, halogenated activated carbons (HACs), is in the research and testing phase in parallel with the development of Toxecon®. HACs are specialized activated carbons that are effectively demonstrating 90% or greater mercury removal efficiency in most subbituminous coal trials without Toxecon®. This has even been measured in dry flue gas desulfurization systems, (*DOE, 2007*). The exception is the lower mercury removal efficiency experienced in hot-side electrostatic precipitator systems where HACs could only achieve 70% removal. This type of electrostatic precipitator configuration is used for particulate control at four coal-fired EGUs in Wisconsin. A Toxecon® system may still be an appropriate option for these units. The development of HACs has also improved the performance of Toxecon® and as an additional benefit reduced amount of sorbent needed to achieve high removal efficiencies.

Another absorption technology development involves the injection of halogen salts, merclean® or KNX®, with activated carbon to improve mercury removal efficiency. Other than for hot-side electrostatic precipitators, tests have shown mercury removal efficiency of 95% on the same EGU achieving 90% in some cases with lower sorbent injection rates (*Sjostrom, 2006; DOE, 2007*).

With the development of Toxecon®, halogenated activated carbons, and oxidizing chemicals a 90% or greater mercury removal efficiency is feasible for bituminous and subbituminous coal-fired EGUs in Wisconsin. However, the cost of fly ash disposal is still an issue that must be weighed in the selection of a mercury control approach for existing EGUs, since it can add considerable cost to the control technology.

Fly Ash Use and Disposal

A critical issue for many of the electric utilities in Wisconsin is the affect of activated carbon on the reuse of fly ash as a concrete additive. Activated carbon makes the fly ash unusable for this purpose. As a result, fly ash contaminated with activated carbon would require placement in a landfill. This is primarily an issue for large subbituminous coal-fired EGUs, greater than 150 megawatts. The older, smaller, coal-fired EGUS in the state generally operate at lower combustion efficiency and as a result have high unburned carbon levels that already make the fly ash unsuitable for concrete. The type of coal combusted also has an effect on the suitability of fly ash. Fly ash from bituminous coal-fired EGUs does not have the right chemical characteristics for use as a cement additive. To date, research and testing has determined that mercury captured by activated carbon is very stable in fly ash and not very likely to be released into the environment (*Sjostrom, 2006*).

For Wisconsin's large coal-fired EGUs there are two options available for avoiding fly ash impacts:

1. A Toxecon® system or dry scrubbing fabric filter system used for sulfur dioxide control with sorbent injection for mercury control.
2. An oxidation catalyst or chemical injection with an existing fabric filter or a wet scrubber system.

Under the first option, the bulk of fly ash (> 95%) is collected by existing particulate control equipment and the remaining fly ash (< 5%) captured in the added fabric filter may require disposal. Under the second option, there is no added carbon and therefore no fly ash contamination.

Where a dry scrubbing fabric filter system is being used for sulfur dioxide control the resulting product is typically disposed of in a landfill. Therefore there is no added impact due to mercury control. Dairyland Power Cooperative is slated to install spray dry adsorption on units at their Genoa and J.P. Madgett Power Plants after existing electrostatic precipitators (*Dairyland, 2007*). Other EGUs in Wisconsin for which this may be a chosen mercury control include Wisconsin Public Service Corporation Weston 3 and units at WE Energies Valley Power Plant. Weston 4, a new coal-fired unit currently under construction will install the combination of spray dry adsorption and mercury absorption respectively for sulfur dioxide and mercury removal.

Other alternatives to activated carbon injection are being evaluated that would address the contamination of fly ash concern and be effective at coal-fired power plants using either a fabric filter or electrostatic precipitator as the primary particulate control system. Although not at the point of commercial application like activated carbon injection, the tests of activated carbon and mineral based absorbents that are not fly ash contaminants are demonstrating effective mercury removal (*IEPA, 2006*). For hot side electrostatic precipitators high temperature mineral based absorbents are at the testing stage (*Levin, 2007*).

An approach similar to Toxecon® is being evaluated where activated carbon is injected into the back portion of an existing electrostatic precipitator after the majority of fly ash has already been collected. A 50% to 80% mercury removal is expected from this approach (*Chang, 2007*). Techniques are also being developed to remove or effectively treat carbon in fly ash to make it suitable for use in cement.

There are mercury control technologies currently available and emerging that minimize fly ash reuse concerns and still achieve a 90% mercury removal.

Costs of Mercury Controls

The cost of mercury control technology applicable to coal-fired EGUs found in Wisconsin are reasonable and cost-effective. These technologies, including sorbent injection with a Toxecon® system or with existing particulate control equipment, are commercially available and will be capable of achieving 90% reduction. Similar control efficiencies can be achieved at lower cost when mercury control is integrated into a multipollutant control systems. Multipollutant approaches are preferred because environmental and public health benefits can be achieved at lower costs.

National Energy Technology Laboratory Mercury Control Technology Field Testing Program

The United States Department of Energy's (DOE) National Energy Technology Laboratory (NETL) initiated mercury control technology research for coal-fired EGUs in the early 1990s. The research and testing of promising control technologies by the NETL accelerated beginning in 2000 with a goal of establishing cost-effective mercury control technology capable of achieving 90% or greater mercury capture that is ready for commercial demonstration by 2010.

The NETL has managed field tests of mercury control technologies at 50 electric generating facilities over the past seven years. Primarily because of the success of their research the NETL reported that as of October 2007, over 70 full-scale activated carbon injection systems have been ordered for installation on coal-fired EGUs (*DOE/NETL, 2008*). These installations have the potential to remove more than 90% of mercury from coal at a cost that is as low as \$10,000 per pound mercury removed.

Control Technology Cost

Table 3-2 presents mercury control costs determined during development of the existing state mercury rule, adopted in 2004, and costs based on the review for this finding of available mercury control technologies appropriate for Wisconsin coal-fired EGUs including the recent advancements in mercury absorption and oxidation approaches. Multipollutant control approaches integrating mercury control are included in the cost evaluation. All include consideration of the cost of fly ash disposal, where appropriate. The comparison of updated mercury controls with costs developed for the 2004 rule demonstrate that control costs have decreased while control effectiveness has increased.

Table 3-2 Estimated Mercury Control Technology Costs

| <i>Mercury Control Technology</i> | <i>EGU Size and Expected Mercury Control Efficiency</i> | <i>Mercury Control Cost COE (cents/kWh)</i> | <i>Cost Reference</i> | <i>Fly ash Impact</i> |
|---|---|---|--|--|
| 2004 Wisconsin State Rule Technology Assessment | | | | |
| Toxecon® | Units > 150 MW @90% | 0.19 – 0.30 | Technical Support Document for the Existing State Mercury Rule | None |
| Activated Carbon Injection in Advance of Existing Particulate Control Equipment | Units < 150 MW @60 to 80% | 0.06 – 0.16 | | Landfill |
| System Average | 86% to 91% | 0.19 – 0.25 | | |
| 2008 Update – Mercury Control Technology | | | | |
| Toxecon® | Large Units @90% | 0.12 – 0.24 | EPRI & DOE | None |
| Activated Carbon or Halogenated Activated Carbon Injection in Advance of Existing Particulate Control Equipment | ESP – Cold @90% | 0.05 - 0.12 | DOE | Activated Carbon – Landfill ^c Cement Friendly Halogenated – None ^c |
| | Fabric Filter @90% | 0.04 - 0.12 ^a | DOE | |
| | ESP – Hot @50% to 90%* | 0.08 - 0.15 ^b | EPRI | |
| 2008 Update – Integrated Multipollutant and Mercury Control Technology | | | | |
| Halogenated Activated Carbon Injection with Dry Flue Gas Desulfurization | 90 – 95% | 0.04 | DOE | None |
| Selective Catalytic Reduction / Oxidation Catalyst with Wet Flue Gas Desulfurization | 80 – 90% | < 0.1 | EPRI | None |

COE – This cost represents the incremental cost to generating electricity.

^a Lower cost is from injection with a dry FGD system. The upper cost is assumed to be no more than the cost of injection with an electrostatic precipitator system.

^b Control levels for sorbent injection following hot-side ESP is expected to be in the 50-70% range. An option is to convert from hot-side to a cold-side ESP for achieving 90% control using normal sorbents.

The cost of this option is estimated based on the cost of sorbent injection for a cold-side ESP plus 0.03 cents/kWh added for converting a hot-side ESP to a cold-side configuration.

^c Most smaller units are not anticipated to generate fly ash sold for cement reuse and therefore no fly ash impacts. But in the case where fly ash is sold Sorbent Technologies has developed and demonstrated a cement friendly halogenated sorbent (C-PAC). This sorbent achieves 90% mercury removal with no impact on fly ash use in cement (Nelson, 2007). The cost of C-PAC is assumed to be similar to other halogenated sorbents.

Under the 2004 rule the overall mercury control cost varied from 0.19 to 0.25 cents per kilowatt-hour (cents/kWh) at mercury removal efficiencies ranging from 86% to 91%. In the 2004 rule, units less than 150 MW were evaluated on the basis of controlling mercury through activated carbon injection without a Toxecon® system. The addition of a fabric filter dedicated to mercury control was determined to be too costly at that time.

Now the cost of a Toxecon® system and sorbent injection with existing particulate control equipment are equitable with costs in the range of 0.04 to 0.24 cents/kWh and both approaches achieving 90% mercury removal for all Wisconsin EGUs regardless of size. These costs are based on DOE estimates from recent full-scale testing specifically targeted to enhance mercury control and reduce costs (DOE, 2007).

The cost of sorbent injection alone for small EGUs with a hot-side electrostatic precipitator maybe as high as 0.24 cents/kWh while achieving a 70% mercury removal efficiency (Levin, 2007). A lower cost option is to convert the electrostatic precipitator to a cold-side configuration with a cost of approximately 0.15 cents/kWh. This situation applies to two EGUs comprising 293 MW out of 833 MW of our small unit capacity (Table 3-2). However, the installation of dry flue gas desulfurization systems at both units is being considered for control of sulfur dioxide emissions. Mercury control cost for this multipollutant control system is comparable to or below mercury control costs for other configurations.

Another significant reduction in control cost is the current availability of the multi-pollutant options. The mercury portion of multi-pollutant control costs could be as little as 0.04 to 0.1 cents/kWh while providing mercury removal efficiencies in the range of 80% to 95%. The lower end of this range reflects the mercury removal efficiency anticipated on a wet scrubber. It is expected that wet scrubber systems can improve mercury control performance to a 90% removal with the application of an appropriate mercury oxidation approach.

Cost-effectiveness

Cost-effectiveness of mercury control is determined by comparing the estimated mercury control costs in Table 3-2 to control technology cost targets set by the Department of Energy (DOE) for mercury control and control costs incurred by electric utilities for other pollutants like nitrogen oxides, particulate matter and sulfur dioxide (Levin, 2007) (Table 3-3).

Table 3-3 Reference Control Costs

| | <i>Cost of Electricity (cents/kWh)</i> | | <i>Expected Control Level</i> | |
|--|--|--------------|-------------------------------|--|
| | <i>Mercury Only</i> | <i>Total</i> | <i>Mercury</i> | <i>SO₂ / NO_x / Particulate</i> |

| DOE and EPRI Reference Control Costs | | | | |
|---|-------------|-----------|-----|-----------|
| Mercury Control Cost Target (25% to 50%) | 0.11 – 0.23 | | 70% | |
| Wet Flue Gas Desulfurization | | 0.9 – 1.2 | | 95% – 98% |
| Sulfur Dioxide Control Dry Flue Gas Desulfurization | | 1.0 – 1.4 | | 90% – 95% |
| Nitrogen Oxides Control Selective Catalytic Reduction | | 0.5 – 0.7 | | 90% |

The goal of the DOE research and development program is to ensure that cost-effective and reliable mercury control is available for the existing coal-fired EGUs (DOE, 2007). DOE set a cost target equivalent to 25% to 50% of the costs estimated in 1999 of \$50,000 to \$70,000 per pound of removed mercury for achieving a 70% reduction (DOE, 2007). As presented in Table 3-3, these DOE cost targets relate to an added cost of electricity (COE) on the order of 0.11 to 0.23 cents per kilowatt-hour (kWh). The reference mercury control costs are well below the reference costs for controlling other pollutants, 0.5 to 1.4 cents/kWh.

In addition, the updated mercury controls presented in Table 3-2 demonstrate that in all cases costs are comparable to or are well within the DOE cost target set for a 70% mercury removal. It should also be noted that, with limited exception, these updated costs reflect controls achieving a 90% mercury removal and exceed the DOE cost-effectiveness target. Based on these comparisons, a 90% control of mercury from coal-fired EGUs is cost-effective. Additional reductions in cost and achievement of higher mercury removal efficiencies will likely occur as emerging technologies become commercially available and commercially available technologies become more widespread.

Section 4 - Compare mercury emission standards proposed with those from neighboring states (“A comparison of the emission standards for hazardous air contaminants in this state to hazardous air contaminant standards in Illinois, Indiana, Michigan, Minnesota, and Ohio” - s. 285.27(2)(b)4., Wis. Stats.)

Summary of Wisconsin’s Current Mercury Rule

Citizen interest and concern about mercury contamination in Wisconsin’s environment significantly influenced the development of Wisconsin’s current mercury rule that became effective October 1, 2004 (*Chapter NR 446, Wis. Adm. Code*). A citizen petition, received in May 2000 and amended in November 2000, from a broad-based group of concerned individuals prompted the department to develop rules to limit mercury air emissions from coal-fired utility boilers. Petition signers included public health professionals, legislators from both major political parties, fishing organizations, Native American Tribes and environmental groups.

Wisconsin’s current rule requires the state’s four major utilities, Alliant Energy, Dairyland Power Cooperative, WE Energies and Wisconsin Public Service Corporation, to reduce their mercury emissions from their existing units in two phases using a baseline determined in 2005. A 40% reduction is required by 2010 and a 75% reduction is required by 2015. In addition, a mercury emission cap, based on actual operating data collected as part of the baseline determination, becomes effective on January 1, 2008.

The rule also establishes a goal of 80% reduction by 2018 to encourage additional progress. Collectively, the state’s four major utilities operate 42 coal-fired EGUs. Wisconsin’s rule does not require a specific control technology. Instead, each utility can select the approach it determines most cost-effective and best meeting their system needs.

The average cost for each homeowner was determined to be \$20 annually to meet the 80% reduction goal. Total cost for the four major utilities in the state to meet the 80% goal was estimated to be \$100 million annually (*Wisconsin DNR, 2003*). By 2015, the state’s regulation could prevent 2,000 pounds of mercury from being released into the air every year.

Proposed Revisions to Wisconsin’s Current Mercury Rule

In recognition of the advancements that have occurred in mercury control technology since the development of the current state mercury rule in 2003, including improved effectiveness and lower cost, it is appropriate to establish a revised mercury rule that will achieve greater mercury emission reductions from coal-fired EGUs. Based upon mercury emission information established in the current state rule, the proposed revisions could prevent 4,400 pounds of mercury from being emitted from coal-fired EGUs in the state (**Table 4-1**).

The proposed revisions will achieve more reductions, affect more coal-fired EGUs in the state and, unlike the current rule; new coal-fired EGUs must meet a stringent mercury control technology standard. Under the current state mercury rule four electric utilities are affected, Alliant Energy, Dairyland Power Cooperative, WE Energies and Wisconsin Public Service Corporation, and the 42 units they operate. The proposed revisions will cover an additional six units operated by four additional utilities, Madison Gas & Electric Company, Manitowoc Public Utilities, Mid-American Energy Company and Xcel Energy.

Under these revisions, the state’s large coal-fired EGUs (150 MW and greater) must comply with one of two compliance paths to achieve a 90% mercury emission reduction. Small coal-fired EGUs (> 25 MW and < 150 MW) must reduce their mercury emissions to a level defined as Best Available Control Technology (BACT).

Table 4-1 Estimated Annual Mercury Emissions from Existing and New Coal-Fired Electrical Generating Units in Wisconsin – Pounds per Year

Existing Coal-fired EGUs

| Size Range in Megawatts | Megawatts | Mercury in Coal | Mercury Control Currently Achieved | Annual Mercury Emissions | Annual Emissions Under Proposed Rule | | Mercury Removed From the Environment |
|-------------------------|--------------|-----------------|------------------------------------|--------------------------|--------------------------------------|------|--------------------------------------|
| | | | | | @90% | @80% | |
| >150 MW | 5,083 | 2,831 | 10% | 2,559 | 283 | | 2,548 |
| >25 to <150 MW | 1,465 | 527 | 12% | 463 | 105 | | 422 |
| | 6,548 | 3,358 | | 3,022 | 388 | | 2,970 |

New Coal-fired EGUs Under Construction

| | Megawatts | Mercury in Coal | Permitted Mercury Control | Annual Mercury Emissions | Annual Emissions Under Proposed Rule | | Mercury Removed From the Environment |
|-----------------------------|--------------|-----------------|---------------------------|--------------------------|--------------------------------------|--|--------------------------------------|
| Elm Road Generating Station | 1,200 | 1,144 | 90% | 114 | 114 | | |
| Weston 4 | 519 | 418 | 83% | 71 | 42 | | |
| | 1,719 | 1,563 | | 185 | 156 | | 1,406 |

| | | | | | | | |
|--------------|--------------|--------------|--|--------------|------------|--|--------------|
| Total | 8,267 | 4,920 | | 3,207 | 544 | | 4,376 |
|--------------|--------------|--------------|--|--------------|------------|--|--------------|

Below is a detailed summary of the more stringent state mercury reduction requirements.

2010 - 2014 Current Mercury Rule Reduction Requirement

Beginning January 1, 2010, the state’s four major utilities must reduce mercury emissions by 40% from the baseline established under provisions in the current state mercury rule. This reduction applies to the 42 existing coal-fired electrical generating units (EGUs) operated by Alliant Energy, Dairyland Power Cooperative, WE Energies and Wisconsin Public Service Corporation.

New EGU Emission Standards

After the effective date of the rule, new coal-fired EGUs must meet Lowest Achievable Emission Rate (LAER) for mercury emissions. In no case shall the permitted mercury reduction be less than 90% removal of mercury from coal combusted.

Large EGU Mercury Emission Standard

By January 1, 2015 existing coal-fired EGUs with nameplate capacity of 150 MW or greater must achieve a 90% mercury reduction, as measured from mercury in coal combusted, or limit the concentration of mercury emissions to 0.0080 pounds mercury per gigawatt-hour. Compliance must be demonstrated annually on a unit-by-unit basis. However, large units under common ownership or control can average to meet the mercury emission standard.

Small EGU Mercury Emission Standard

By January 1, 2015 existing coal-fired EGUs with a nameplate capacity greater than 25 MW but less than 150 MW must achieve a level of mercury emissions defined as Best Available Control Technology (BACT). Owners or operators would propose BACT for small units within 24 months of the effective date of the rule. Owners or operators have the option to decide if units in this size range are placed in the large unit compliance pathway.

Large EGU Multipollutant Option

Under this alternative, EGUs with nameplate capacity of 150 MW or greater must achieve NO_x and SO₂ reductions beyond those currently required by federal and state regulations, as well as attain a delayed 90% mercury emission reduction standard. Owners and operators must designate which EGUs with 150 MW or greater nameplate capacity will follow the multipollutant option within 24 months after the effective date of the rule. Large EGUs that are not designated for the multipollutant option will, by default, be required to achieve the large EGU mercury emission standard.

Under the multipollutant option, affected EGUs must achieve a nitrogen oxides (NO_x) emission standard of 0.07 pounds per million BTU and a sulfur dioxide (SO₂) emission standard of 0.10 pounds per million BTU by January 1, 2015. An additional six years to achieve a 90% mercury emission standard is provided to EGUs included in a multipollutant reduction approach. Compliance must be demonstrated annually on a unit-by-unit basis. However, large units under common ownership or control can average to meet the NO_x, SO₂, or mercury emission standard.

An interim mercury reduction requirement is established that targets January 1, 2015 to achieve a 70% mercury reduction as measured from the mercury content of coal combusted or limit the concentration of mercury emissions to 0.0190 pounds mercury

per gigawatt-hour. Beginning January 1, 2018 an 80% mercury reduction as measured from the mercury content of coal combusted or limit the concentration of mercury emissions to 0.0130 pounds mercury per gigawatt-hour must be achieved. By January 1, 2021 a 90% mercury reduction, as measured from mercury in coal combusted, or limit the concentration of mercury emissions to 0.0080 pounds mercury per gigawatt-hour is required.

The reduction in emissions expected from the large and small EGU mercury emission requirements and the large EGU multipollutant option are presented in **Table 4-2**. If all large EGUs elected to achieve a 90% mercury reduction by 2015 mercury emissions would be approximately 536 pounds per year. If all large EGUs elected to follow the multipollutant option mercury emissions would still be reduced to 536 pounds however, this is not achieved until 2021. Substantial reductions in sulfur dioxide and nitrogen oxide emissions would however be achieved by 2015 under the multipollutant option. These reductions of pollutants other than mercury have significant benefit to Wisconsin and address other critical air quality concerns including fine particles, haze, and ground level ozone.

Table 4-2 – Estimated Mercury, Nitrogen Oxides (NOx) and Sulfur Dioxide (SO2) Reductions from the Proposed Wisconsin Mercury Reduction Rule

Mercury Emissions - 90% Mercury and Multipollutant Compliance Paths (pounds per year)

| Year | All Large Units 90% by 2015 Small Units BACT @ 80% | All Large Units Multipollutant @ 70%, 80% & 90% Small Units BACT @ 80% |
|------|---|---|
| 2015 | 536 | 1,102 |
| 2018 | 536 | 819 |
| 2021 | 536 | 536 |

Nitrogen Oxides and Sulfur Dioxide Emissions - Multipollutant Compliance Path (tons per year)

| Pollutant | 2005 Emissions | 2015 Estimated Emissions | |
|---------------------|----------------|---------------------------------|--|
| | | All Large Units Mercury Pathway | All Large Units Multipollutant Pathway |
| Nitrogen Oxides | 39,599 | 27,718 | 14,966 |
| Reduction from 2005 | | 30% | 62% |
| Sulfur Dioxide | 118,153 | 89,213 | 21,422 |
| Reduction from 2005 | | 24% | 82% |

Early Emission Reduction Credits

For the multipollutant pathway, reductions in excess of mercury emission reduction requirements, certified by the Department, can be used to meet a portion of the annual allowable mercury emissions. Early mercury emission reduction credits can be used for up to 5% of the annual allowable emission total, in pounds, to achieve compliance with the 70%, 80% and 90% mercury reduction standard. Reductions achieved greater than the 70% or 80% mercury emission standard and the 2010 requirement for the major utilities to reduce emissions 40% from a baseline established under the existing state rule also

qualify as early mercury emission reduction credits. Early emission reduction credits are not transferable to another utility.

Review of Rule Requirements

A review of rule requirements during 2010 to 2014 will be conducted to evaluate mercury control technology and consider if the schedule to achieve 90% on EGUs 150 MW and larger is appropriate. An element of this review will be a determination whether additional compliance flexibility is warranted to achieve the January 1, 2021, 90% mercury emission reduction standard under the alternative multipollutant option.

Summary of State Mercury Programs in EPA's Region 5

In addition to Wisconsin, the other states in EPA's Region 5 include Illinois, Indiana, Michigan, Minnesota, and Ohio. Below is a summary of the rules or laws in effect or under development in these states to reduce mercury air emissions from coal-fired power plants. A Region 5 state mercury program summary table is included in the appendices (**Appendix B**). Among the states in EPA's Region 5, Illinois, Michigan and Minnesota are proposing or have adopted requirements more stringent than the CAMR would have achieved including more mercury emission reductions sooner. Illinois and Michigan declined participation in EPA's national trading program. Ohio and Indiana developed regulations to adopt EPA's national trading program to meet CAMR requirements.

Indiana – On October 3, 2007 the Indiana Air Pollution Control Board adopted a state regulation that parallels the model rule EPA developed for states to meet the CAMR (326 IAC 24-4). Indiana coal-fired EGUs were allowed to participate in EPA's national trading program. The schedule and amount of mercury reductions required in their regulation matched the mercury emission budget set for Indiana in the CAMR.

Ohio - Ohio regulations to address the CAMR became effective in May 2007 (OAC 3745-108). Like Indiana, Ohio adopted EPA's model rule to implement the CAMR. Ohio planned to achieve their annual mercury emission budget according to the schedule established in the CAMR. Their regulations required mercury reductions greater than the state emission budget EPA established and compliance would have been achieved through EPA's national trading program.

Illinois - Regulations that became effective in December 2006 require coal-fired EGUs in operation as of December 31, 2008 to reduce mercury emissions by 90% as measured from the mercury content of coal combusted or achieve an output based emission standard of 0.008 pounds mercury per gigawatt-hour (35 Ill. Adm. Code 225). Compliance for either standard is determined on a rolling 12-month average. These reductions must be achieved by January 1, 2009 unless a system-wide multipollutant approach is employed. Emission averaging with other units is allowed until December 31, 2013 provided each unit involved achieves a 75% mercury emission reduction or meets an emission standard of 0.02 pounds mercury per gigawatt-hour.

Under a system-wide multipollutant approach, compliance with the control standard for mercury is extended until January 1, 2015. Limitations for nitrogen oxides and sulfur dioxide must also be achieved. This is a permanent commitment and opting out of this compliance option is not allowed. Units planned for permanent retirement can be exempted provided notice is given and unit shutdown occurs no later than June 30, 2011.

Illinois declined participation in EPA's national trading program. For compliance demonstration the emission monitoring requirements included in the federal CAMR are required.

New power plants, beginning January 1, 2009 must achieve on a rolling 12-month average a 90% reduction of mercury from coal combusted or achieve an output based emission standard of 0.008 pounds mercury per gigawatt-hour upon start-up. This requirement does not apply to replacement of units at an existing power plant. A temporary technology standard is available for new power plants that can extend the mercury compliance date until December 31, 2018. The temporary standard requires Best Available Control Technology (BACT) for nitrogen oxides, particulate matter, and sulfur dioxide emissions and application of an approved mercury control technology.

Michigan - The State of Michigan is developing a regulation to address mercury emissions from their coal-fired electric utilities. Michigan Governor Granholm directed the Michigan Department of Environmental Quality to develop a rule to reduce mercury emissions from coal-fired electric utilities 90 percent by 2015. Public comments on a draft rule were accepted in fall 2007 (*SOAHR 2005-038 EQ*).

Under this proposal, existing coal-fired EGUs must reduce mercury emissions by 90% as measured from the mercury content of coal combusted or limit the concentration of mercury emissions to 0.008 pounds mercury per gigawatt-hour by January 1, 2015. Compliance can be achieved on unit-by-unit bases or through plant-wide or system-wide averaging. The compliance approach can be different from year-to-year. A multipollutant proposal that achieves at least a 75% reduction as measured from the mercury content of coal combusted is available as an alternative. Small units, defined as those that emit less than 9 pounds of mercury emissions annually, can comply under an alternative plan. A request for system-wide averaging or a multipollutant approach can be disapproved if local mercury impacts are demonstrated. New units, constructed after January 30, 2004 must install BACT for mercury which achieves mercury reductions at least as stringent as the standard for existing units.

Beginning in 2010 annual emission caps are established for each unit through the distribution of the mercury emission budget EPA set for Michigan in the CAMR. The procedure for setting emission caps for each unit considers the highest three-year heat input average from the most recent five-year period. In 2015 and beyond, annual unit specific caps are set based on BACT, an approved alternative compliance approach, or either 90% reduction from a baseline based on mercury in coal combusted or output

based emission standard of 0.008 pounds per gigawatt-hour annual average. In 2016 and 2017 emission caps for existing units can be adjusted to account for exceptional circumstances that may prevent a unit from achieving compliance (e.g. unavoidable delay in the installation of control equipment). Units affected do not receive mercury allowances. Instead mercury emission caps are established by procedures that ensured that the CAMR state mercury emission budget was not exceeded. Retired units do not receive a mercury emission cap.

Minnesota - The Minnesota Mercury Reduction Act enacted in May 2006 establishes a 90% mercury removal requirement for the six largest EGUs in the state (*H.F. No. 3712.3*). This requirement is expected to reduce statewide mercury emissions from coal-fired power plants in Minnesota 70% by 2015.

The reductions are based on a determination of mercury emissions using the monitoring methods and procedures established in the CAMR and must include at least six months of measurements. For those units equipped with a spray dryer and fabric filter for control of air contaminants, a mercury control plan is required by December 31, 2007, and must be implemented by December 31, 2010. If an owner has two dry scrubbed units, implementation at one unit must be achieved by December 31, 2009. For those units equipped with a wet scrubber for control of air contaminants, plans are required by December 31, 2009 and implementation must occur by December 31, 2014. Deadline extensions are allowed however, final compliance cannot be extended more than 12 months.

The plans required must identify the controls necessary to achieve a 90% reduction in emissions. The required mercury reduction level is fixed in a permit after completion of a start-up period. Emission monitoring data and consideration of expected performance in the upcoming five-year period are considered in establishing the permitted mercury reduction level.

The Minnesota Pollution Control Agency reviews plans and makes recommendations to the Minnesota Public Utilities Commission which has approval authority. Owners can recover costs for monitoring, control equipment, construction, operation and maintenance, relevant studies and other related costs incurred prior to plan approval. Multipollutant control proposals submitted with a mercury plan may also qualify for cost recovery.

National Response of States to the Federal Clean Air Mercury Rule

As of December 7, 2007, 20 states adopted or considered requirements that prohibit or restrict interstate trading of mercury emissions as EPA allowed as an option in the CAMR and 21 states have or proposed requirements that would have achieved more mercury emission reductions than the CAMR (*NACAA Table, December 2007*). State programs in 22 states were mostly consistent with EPA's CAMR model rule that allowed participation in the national mercury trading program. Below is a list of the states in each of these response categories.

- *20 States have or are proposing requirements that prohibit or restrict interstate trading of mercury emissions*
Arizona, California, Colorado, Connecticut, Delaware, Florida, Idaho, Illinois, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Vermont, Virginia & Washington
- *22 States have or are proposing requirements that achieved more mercury emission reductions than the CAMR*
Arizona, California, Colorado, Connecticut, Delaware, Georgia, Illinois, Maryland, Massachusetts, Michigan, Minnesota, Montana, New Hampshire, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Utah, Virginia & Washington, Wisconsin
- *22 States planned to adopt EPA's Model Rule that is no more stringent than CAMR and allowed interstate trading of mercury emissions*
Alabama, Alaska, Arkansas, Hawaii, Indiana, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Nebraska, Nevada, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, West Virginia & Wyoming

Comparison of Wisconsin's Mercury Emission Standards to Mercury Emission Standards in Other States in EPA's Region 5

Below is a summary of similarities and differences between the mercury emission standards and control requirements for coal-fired EGUs in Wisconsin as compared to the other states in EPA's Region 5; Illinois, Indiana, Michigan, Minnesota, and Ohio. The comparison addresses mercury emission reduction requirements and schedules, multipollutant alternatives, and compliance flexibility. A detailed summary and comparison of the Region 5 states mercury emission standards for coal-fired EGUs is included in Appendix B.

Wisconsin, like Illinois, Michigan and Minnesota, is proposing to require large coal-fired EGUs to achieve a 90% reduction based on mercury in coal combusted. Compliance with this mercury emission standard in these state requirements varies from 2009 to 2021. In part this variation can be attributed to the availability of multipollutant reduction options that extends the mercury reduction compliance date in exchange for reductions in sulfur dioxide and nitrogen oxide. Each of these four states has built-in to their requirements compliance flexibility such as emission averaging and less restrictive requirements for small EGUs.

Illinois, Michigan, and Wisconsin have included specific mercury emission standards for new coal-fired EGUs or power plants.

Mercury Emission Reduction Requirements and Schedule

Illinois, Michigan and Minnesota all have law or regulations that require a 90% reduction based on mercury in coal combusted for large EGUs in their states. Michigan requires compliance by January 1, 2015. Illinois requires compliance with their mercury

emission standard by July 1, 2009 and Minnesota established a compliance date of December 31, 2010 or December 31, 2014 depending upon the type of sulfur dioxide or nitrogen oxide emission control system being used. The Minnesota Emission Reduction Act of 2006 only affects six EGUs located at the state's three largest power plants however; this will result in a 70% reduction in mercury emissions from all coal-fired EGUs in this state. The mercury emission standard proposed for Wisconsin requires large EGUs to achieve a 90% mercury reduction, as measured from mercury in coal combusted, by January 1, 2015.

In Indiana and Ohio there are no specific mercury reduction requirements for coal-fired EGUs. These states developed regulations to meet the now vacated CAMR through participation in EPA's national trading program.

More restrictive requirements for new coal-fired EGUs or new coal-fired power plants have been established in Illinois and in Michigan. In Illinois new coal-fired power plants, after January 1, 2009, are required to meet the state's 90% mercury reduction requirement upon start-up with the ability to meet a temporary technology standard until January 1, 2019. New coal-fired EGUs in Michigan, after January 1, 2004, must achieve the state's 90% mercury reduction requirement with the possibility that a more stringent requirement may be imposed. The Wisconsin proposal for new coal-fired EGUs is similar to Michigan's requiring mercury emissions to be controlled to a level defined as Lowest Achievable Emission Rate but in no case less than 90% removal of mercury from coal combusted. This new unit requirement in Wisconsin would become effective upon rule promulgation.

Multipollutant Alternatives

All coal-fired EGUs participating in the Illinois multipollutant option may delay compliance with the 90% mercury emission standard until January 1, 2015 provided that specific sulfur dioxide and nitrogen oxide limitations are met. Michigan also offers a multipollutant option with sulfur dioxide and nitrogen oxides emission standards that lowers the mercury reduction requirement from 90% to 75% mercury removal from coal combusted but does not alter the January 1, 2015 compliance date.

The Wisconsin multipollutant proposal requires sulfur dioxide and nitrogen oxide reductions by January 1, 2015 and allows participating EGUs until January 1, 2021 to achieve the 90% mercury standard. An interim mercury standard for these EGUs must be achieved by January 1, 2018.

Compliance Flexibility

Averaging among coal-fired EGUs can be used to demonstrate compliance with the 90% mercury emission standard in Illinois until December 31, 2013 provided that each unit achieves a 75% reduction of mercury in coal combusted. An individual unit or multiple units may demonstrate compliance with the Illinois mercury emission standard by demonstrating that actual emissions are less than allowable emissions over a rolling

12-month period. These alternative compliance demonstrations are limited to EGUs under common ownership or operation. Illinois exempts coal-fired EGUs that will be permanently shutdown by December 31, 2010 or December 31, 2011, if a new construction is involved.

In Michigan compliance can be demonstrated unit-by-unit, power plant-wide or system-wide at the choice of an owner or operator. The compliance approach can also change from year-to-year at the owner or operators discretion with advance notification. Small coal-fired EGUs, with mercury emissions less than 9 pounds per year, can propose an alternative reduction plan. Technical or economic exceptions to the mercury emission standard may also be provided.

Minnesota allows up to a 12-month extension to their compliance dates and units that are equipped with wet scrubbers to reduce sulfur dioxide emissions can substitute a different unit for a targeted unit in their mercury control law.

Under the Wisconsin rule proposal, coal-fired EGUs under common ownership or control may average to achieve the proposed mercury emission standard or multipollutant requirements for sulfur dioxide and nitrogen oxide.

REFERENCES

Overview

Federal Clean Air Mercury Rule – Standards of Performance for New and Existing Stationary Sources: Electric Utility Steam Generating Units, 40 CFR Parts 60, 63, 72 and 75

http://www.epa.gov/air/mercuryrule/pdfs/camr_final_preamble.pdf

Section 1

Knobeloch, L., Steenport, D., Schrank, C. and Anderson, H.A., 2006. Methylmercury exposure in Wisconsin: A case study series. *Environ. Res.* 2006 May; 101(1):113-22. Epub 2006 Sep 29.

Mergler, D., Anderson, H., Chan, L., Mahaffey, K., Murray, M., Sakamoto, M. and Stern, A. 2007. Methylmercury exposure and health effects in humans: a worldwide concern. *Ambio* 36, 3-11.

USEPA 2007 Mercury Reference Dose, Integrated Risk Information System On-line Database
www.epa.gov/iris.

Section 2

Agency for Toxic Substances and Disease Registries. 1999. Toxicological Profile for Mercury. Agency for Toxic Substances and Disease Registries, US Dept of Health and Human Services, Atlanta, GA.

Burgess, N.M. and Meyer, MW. 2008. Methylmercury exposure associated with reduced productivity in common loons. *Ecotoxicology* 17(2): 83-91.

Engstrom, D. R. and Swain, E. B. 1997. Recent declines in atmospheric mercury deposition in the upper Midwest. *Environ. Sci. Technol.* 31(2): 60-67.

Evers, D. C. , Han, Y.J., Driscoll, C.T., Kamman, N.C., Goodale, M.W., Lambert, K.F., Holsen, T.M., Chen, C.Y., Clair, T.A. and Butler, T. 2007. Biological Mercury Hotspots in the Northeastern United States and Southeastern Canada. *BioScience* 57(1): 29-43.

Fitzgerald, W.F., Engstrom, D.R., Mason, R.P. and Nater, E.A. 1998. The case for atmospheric mercury contamination in remote areas. *Environ. Sci. Tech.* 32(1): 1-7.

Gilmour, C.C. and Henry, E.A. 1991. Mercury methylation in aquatic systems affected by acid deposition. *Environ. Pollut.* 71: 131-149.

Hammerschmidt, C. R., Wiener, J. G., Frazier, B. E. and Rada, R.G. 1999. Methylmercury content of eggs in yellow perch related to maternal exposure in four Wisconsin lakes. *Environ. Sci. Technol.* 33, 999-1003.

Harris, R.C., Rudd, J.W., Amyot, M., Babiarz, C.L., Beaty, K.G., Blanchfield, P.J., Bodaly, R.A., Branfireun, B.A., Gilmour, C.C., Graydon, J.A., Heyes, A., Hintelmann, H., Hurley, J.P., Kelly, C.A., Krabbenhoft, D.P., Lindberg, S.E., Mason, R.P., Paterson M.J., Podemski C.L., Robinson, A., Sandilands, K.A., Southworth, G.R., St Louis, V.L., and Tate, M.T. 2007. Whole-ecosystem study shows rapid fish-mercury response to changes in mercury deposition. *Proc Natl Acad Sci U S A.* 2007 Sep 27; [Epub ahead of print].

- Hrabik T. R. and Watras, C.J. 2002. Recent declines in mercury concentrations in a freshwater fishery: isolating the effects of de-acidification and decreased atmospheric mercury deposition in Little Rock Lake. *Sci. Total Environ* 297:229-237.
- Johansson, K., Bergback, B. and Tyler, G. 2001. Impact of atmospheric long range transport of lead, mercury and cadmium on the Swedish forest environment. *Water Air Soil Pollut. Focus* 1: 279-297.
- Keeler, G.J., Landis, M.S., Norris, G.A., Christianson, E.M., and Dvonch, J.T. 2006. Sources of Mercury Wet Deposition in Eastern Ohio, USA. *Environ. Sci. Technol.*, 40 (19), 5874 -5881, 2006.
- Kenow, KP, Grasman, KA, Hines, RK, Meyer, MW, Gendron-Fitzpatrick, A, Spalding, M, Gray, BR. 2007. Effects of methylmercury exposure on the immune function of juvenile common loons. *Environmental Toxicology and Chemistry* 26: 1460-1469.
- Knobeloch L. Population-based methylmercury exposure assessment. Final report to State of Wisconsin, Department of Administration, Division of Energy. August, 2005.
- Knobeloch, L., Anderson, H.A., Imm, P., Peters, D. and Smith, A 2005. Fish consumption, advisory awareness, and hair mercury levels among women of childbearing age. *Env Research.* 97:220-227.
- Knobeloch, L., Steenport, D., Schrank, C. and Anderson, H.A., 2006. Methylmercury exposure in Wisconsin: A case study series. *Environ. Res.* 2006 May; 101(1):113-22. Epub 2005 Sep 29.
- Knobeloch, L., Gliori, G., and Anderson, H.A. 2007. Assessment of methylmercury exposure in Wisconsin. *Environ. Res.* 103(2):205-10.
- Lindberg, S., Bullock, R., Ebinghaus, R., Engstrom, D., Feng, X., Fitzgerald W., Pirron, N., Prestbo, E. et al. 2007. A synthesis of progress and uncertainties in attributing the sources of mercury in deposition. *Ambio* 36, 19-32.
- Madsen, E.R. and Stern, H.S. 2007. Time trends of methylmercury in walleye in northern Wisconsin: a hierarchical Bayesian analysis. *Environmental Science and Technology* 41: 4568-4573.
- McDowell, M. A., Dillon, C.F., Osterloh, J., Bolger, P.M., Pellizzari, E., Fernando, R., de Oca, R.M., Schober, S.E. et al. 2004. Hair mercury levels in US children and women of childbearing age: reference range data from NHANES 1999-2000. *Environ. Health Perspect.* . 112 1165-1171.
- Mergler, D., Anderson, H., Chan, L., Mahaffey, K., Murray, M., Sakamoto, M. and Stern, A. 2007. Methylmercury exposure and health effects in humans: a worldwide concern. *Ambio* 36, 3-11.
- Meyer, M.W., Evers, D.C., Daulton, T. and Braselton, W.E. 1995. Common loons (*Gavia immer*) nesting on low pH lakes in northern Wisconsin have elevated blood mercury content. *Water Air Soil Pollut.* 80, 871-880.
- Meyer, M.W., Evers, D.C., Hartigan, J.J. and Rasmussen, P.S. 1998. Patterns of common loon (*Gavia immer*) mercury exposure, reproduction, and survival in Wisconsin, USE. *Environ. Toxicol. Chem.* 17, 184-190.
- Meyer, M.W. 2006. Evaluating the Impact of Multiple Stressors on Common Loon Population Demographics – An Integrated Laboratory and Field Approach. USEPA STAR Grant R 82-9085, Final Report. July 31, 2006. Rhinelander, Wisconsin, USA.

MPCA (Minnesota Pollution Control Agency) 2005. Minnesota Statewide Mercury Total Maximum Daily Load, Draft June 1, 2006. (<http://www.pca.state.mn.us/publications/wq-iw4-01b.pdf>).

Munthe, J., Hultberg, H., Lee, Y.-H., Parkman, H., Iverfeldt, A. and Renberg, I. 1995. Trends of mercury and methylmercury in deposition, run-off water, and sediments in relation to experimental manipulations and acidification. *Water, Air, Soil Pollut.* 85: 743-748.

Munthe, J., Kindbom, K., Kruger, O., Petersen, G., Pacyna, J. and Iverfeldt, Å. 2001. Examining source-receptor relationships for mercury in Scandinavia. *Water Air Soil Pollut. Focus* 1, 99-110.

Munthe, J., Bodaly, R., Branfireum, B., Driscoll, C., Gilmour, C., Harris, R., Horvath, M., Lucotte, M. et al. 2007. Recovery of mercury-contaminated fisheries. *Ambio* 36, 33-44.

Orihel, D.M., Patterson, M.J., Gilmour, C.C., Bodaly, R.A., Blanchfield, P.J., Hintelmann, H., Harris, R.C. and Rudd, J.W.M. Effect of loading rate on the fate of mercury in mesocosms. *Environ. Sci. Technol.* 40: 5992-6000.

Prestbo, E. M., Leutner, J.M. and Pollman, C.D. 2006. Abrupt decrease in mercury wet-deposition concentrations and annual flux in Seattle, Washington due to emission point-source changes. In: *Proceedings of the International Conference on Mercury as a Global Pollutant*. Madison. www.mercury2006.org

Rasmussen, P. W., Schrank, C. S. and Campfield P. A. 2007. Temporal trends of mercury concentrations in Wisconsin walleye (*Sander vitreus*), 1982–2005. *Ecotoxicology*. Online Version: 27 July 2007. <http://www.springerlink.com/content/w67723u094000164/?p=97fa0af25fde4f74b47fd584e249de8d&pi=0>

St. Louis, V.L., Rudd, J.W.M., Kelly, C.A., Bodaly, R.A.D., Paterson, M.J., Beaty, K.G., Hesslein, R.H. and Majewski, A.R. 2004. The rise and fall of mercury methylation in an experimental reservoir. *Environ. Sci. Tech.* 38: 1348-1358.

Scheuhammer, A., Meyer, M., Sandheinrich, M. and Murray, M. 2007. Effects of environmental methylmercury on the health of wild birds, mammals, and fish. *Ambio* 36, 12-18.

Sills, R.M., Haywood, J., Morgan, J. Taylor, Brunner, J., Hengesbach S. and Depa, M. 2007. Evaluation of Mercury Emission Averaging Scenarios for Electric Generating Facilities in Michigan. External Review Draft June 1, 2007.

Swain, E.B., Engstrom, D.R., Brigham, M.E., Henning, T.A. and Brezonik, P.L. 1992. Increasing rates of mercury deposition in midcontinental North America. *Science* 257: 784-787.

USEPA 2007 Mercury Reference Dose, Integrated Risk Information System On-line Database www.epa.gov/iris.

US National Research Council (US NRC). 2000. *Toxicological Effects of Methylmercury*. National Academy Press, Washington, DC, 344 pp

Watras, C.J., Morrison, K.A., Hudson, R.J.M., Frost, T.M. and Kratz, T.K. 2000. Decreasing mercury in northern Wisconsin: Temporal patterns in bulk precipitation and a precipitation-dominated lake. *Environ. Sci. Tech.* 34(19): 4051-4057.

Watras, C. J., Morrison, K.A., Regnell O. and Kratz, T. K. The methylmercury cycle in Little Rock Lake during experimental acidification and recovery. *Limnol. Oceanogr.* 51(1), 2006, 257-270.

Watras, C. J. and Morrison, K. A. 2008. The response of two remote, temperate lakes to changes in atmospheric mercury deposition, sulfate, and the water cycle. *Can. J. Fish. Aquat. Sci.* 65: 100-116.

World Health Organization – Joint FAO/WHO Expert Committee on Food Additives (WHO-JEFCA). 2003. Letter from WHO-JEFCA committee members to Samuel W. Page, Acting WHO Secretary to JEFCA. June 3, 2003.

Section 3

Campbell, T., 2007. Availability of Mercury Measurement and Control Technology., presentation to the Department of Natural Resources Board. Institute of Clean Air Companies (ICAC), July 18, 2007.

Chang, R., 2007. Mercury Control for Western Coals., presentation to the Department of Natural Resources Board. Electric Power Research Institute (EPRI), July 18, 2007.

Dairyland Power, 2007. Staff Conversation., Department of Natural Resources, Bureau of Air Management, May, 2007.

Illinois Environmental Protection Agency (IEPA), 2006. Technical Support Document for Reducing Mercury Emissions From Coal-Fired Electric Generating Units., Bureau of Air, Division of Air Pollution Control, AQPSTR 06-02, March 14, 2006.

Department of Energy (DOE), 2008. An Update on DOE/NETL's Mercury Control Technology Field Testing Program., prepared by Feeley, T. J. and Jones A.P., January 2008

Department of Energy (DOE), 2007. DOE/NETL's Phase II Mercury Control Technology Field Testing Program, Updated Economic Analysis of Activated Carbon Injection., National Energy Technology Laboratory, prepared by Jones, A.P., Hoffmann, J.W., Smith, D.N., Feeley, T.J. and Murphy, J.T., May 2007.

Department of Energy (DOE), 2006. Mercury Capture and Fate Using Wet FGD at Coal-Fired Power Plants., National Energy Technology Laboratory, August 2006.

Environmental Protection Agency (EPA), 2005. Control of Mercury Emissions from Coal Fired Electric Utility Boilers: An Update., Office of Research and Development, February 18, 2005.

Feeley, T. J. and Jones A.P., An Update on DOE/NETL's Mercury Control Technology Field Testing Program, January 2008

Gretta, W. J., Wu, S., Ph.D., Nagai, Y., and Morris, E.L., 2007. Mercury Oxidation Catalyst for PRB-Boilers., Hitachi Power Systems America, www.hitachi.com, October 2007.

Institute of Clean Air Companies (ICAC), 2007. Commercial Electric Utility Mercury Control Technology Bookings., www.icac.com, August 2007.

Levin, L. Ph.D. 2007. Written Testimony Before the Subcommittee on Clean Air and Nuclear Safety, Committee on Environment and Public Works, United States Senate, Washington, D.C., Electric Power Research Institute (EPRI). May 16, 2007.

Sjostrom, 2006. Mercury Control for PRB and PRB/Bituminous Blends., EUEC 2006 conference presentation, ADA-ES, Inc. Littleton Co. January 24, 2006.

Section 4

Chapter NR 446, Control of Mercury Emissions, Wis. Adm. Code
<http://www.legis.state.wi.us/rsb/code/nr/nr446.pdf>

An Assessment of Major Utility Air Emission Control and Cost – Attachment B, Wisconsin DNR, May 2003
<http://dnr.wi.gov/air/toxics/mercury/rule.htm>

Federal Clean Air Mercury Rule (40 CFR Parts 60, 63, 72 and 75)
http://www.epa.gov/air/mercuryrule/pdfs/camr_final_preamble.pdf

Illinois - Control of Emissions from Large Combustion Sources (35 Ill. Adm. Code 225)
<http://www.ipcb.state.il.us/documents/dsweb/Get/Document-58236/>

Indiana - Proposed Rule to Implement the Clean Air Mercury Rule (326 IAC 24-4)
http://www.in.gov/idem/rules/packets/air/oct/05-116_proposed_rule.pdf

Michigan - Proposed Mercury Rule (SOAHR 2005-038 EQ)
<http://www.deq.state.mi.us/documents/deq-aqd-air-aqe-hg-2005-038EQ-9-25-07.pdf>

Minnesota Mercury Reduction Act of 2006 (H.F. No. 3712.3)
<http://www.revisor.leg.state.mn.us/bin/bldbill.php?bill=H3712.3.html&session=ls84>

Ohio Clean Air Mercury Rule (OAC 3745-108)
http://www.epa.state.oh.us/dapc/regs/3745-108/3745_108.html

National Association of Clean Air Agencies State Mercury Programs for Utilities Table
<http://www.4cleanair.org/Documents/StateTable.pdf>

APPENDIX A

s. 285.27 (2)(b) Wis. Stats. Standard to protect public health or welfare. If an emission standard for a hazardous air contaminant is not promulgated under section 112 of the federal clean air act, the department may promulgate an emission standard for the hazardous air contaminant if the department finds the standard is needed to provide adequate protection for public health or welfare. The department may not make this finding for a hazardous air contaminant unless the finding is supported with written documentation that includes all of the following:

1. A public health risk assessment that characterizes the types of stationary sources in this state that are known to emit the hazardous air contaminant and the population groups that are potentially at risk from the emissions.
2. An analysis showing that members of population groups are subjected to levels of the hazardous air contaminant that are above recognized environmental health standards or will be subjected to those levels if the department fails to promulgate the proposed emission standard for the hazardous air contaminant.
3. An evaluation of options for managing the risks caused by the hazardous air contaminant considering risks, costs, economic impacts, feasibility, energy, safety, and other relevant factors, and a finding that the chosen compliance alternative reduces risks in the most cost-effective manner practicable.
4. A comparison of the emission standards for hazardous air contaminants in this state to hazardous air contaminant standards in Illinois, Indiana, Michigan, Minnesota, and Ohio.

APPENDIX B - Comparison of State Programs in EPA’s Region 5 to Reduce Mercury Emissions from Coal-fired Power Plants

| | Wisconsin | Illinois | Indiana | Michigan | Minnesota | Ohio |
|------------------------------------|--|--|---|--|---|---|
| Mercury Reductions Required | <p>1. <i>Large EGU Mercury Emission Standard</i> - By January 1, 2015, existing coal-fired EGUs with nameplate capacity of 150 MW or greater must achieve a 90% mercury reduction or limit the concentration of mercury emissions to 0.008 pounds mercury per gigawatt-hour. Compliance must be demonstrated annually on a unit-by-unit basis. However, units under common ownership or control can average to meet the mercury emission standard.</p> <p>2. <i>Small EGU Mercury Emission Standard</i> - By January 1, 2015, existing coal-fired EGUs with a nameplate capacity greater than 25 MW but less than 150 MW must achieve a level of mercury emissions defined as BACT.</p> <p>3. New EGUs, proposed after the effective date of the rule, must limit mercury emissions to LAER.</p> | <p>1. 90% as measured from the mercury content of coal combusted or limit the concentration of mercury emissions to 0.008 pounds mercury per gigawatt-hour on a rolling 12-month basis for all units that are in operation as of December 31, 2008.</p> <p>2. Emission averaging, with other units is allowed until December 31, 2013, provided each unit involved achieves a 75% reduction or output emission standard of 0.02 pounds per gigawatt-hour on a rolling 12-month basis.</p> <p>3. New power plants, beginning January 1, 2009, must meet 90% as measured from the mercury content of coal combusted or limit the concentration of mercury emissions to 0.008 pounds mercury per gigawatt-hour on a rolling 12-month basis upon start-up. This requirement does not apply to replacement of units at an existing power plant.</p> | <p>Reductions that meet the annual Indiana mercury emission budget established in the CAMR:</p> <p>Baseline: 4,884 lbs.</p> <p>2010: 4,196 lbs. (14.1%)</p> <p>2018: 1,656 lbs. (66.1%)</p> | <p>1. 90% reduction from a baseline based on mercury in coal combusted or output based emission standard of 0.008 pounds per gigawatt-hour annual average.</p> <p>2. New units (after January 30, 2004) may be subject to more stringent requirements.</p> | <p>90% reduction from mercury emitted from six units located at the three largest power plants in Minnesota. This action will result in a 70% reduction of mercury emissions from coal-fired power plants in Minnesota.</p> | <p>Reductions that meet the Ohio mercury emission budget established in the CAMR:</p> <p>Baseline: 7,109 lbs.</p> <p>2010: 4,114 lbs. (42.1%)</p> <p>2018: 1,624 lbs. (77.2%)</p> |
| Mercury Reduction | 1. Large EGU and small EGU mercury emission | 1. Achieve the required reductions by July 1, | Achieve the annual mercury emission budget | 1. Achieve the required reductions by January 1, | 1. For units equipped with a spray dryer and fabric | Achieve the annual mercury emission budget |

| | Wisconsin | Illinois | Indiana | Michigan | Minnesota | Ohio |
|---|--|---|--|--|--|---|
| Schedule | standards must be achieved by January 1, 2015. 2. For large units, an optional multipollutant compliance pathway extends compliance with the mercury emission standard until January 1, 2021. | 2009. 2. If employing a multipollutant approach, achieve reductions by January 1, 2015. 3. New power plants can meet a temporary technology standard until January 1, 2019. | according to the schedule established in the CAMR – 2010 and 2018. | 2015. 2. Prior to 2015, emission caps are set by distributing the state CAMR budget based on adjusted baseline heat input to all affected electrical generating units. 3. In 2015 and beyond, source specific caps set for each unit based on either 90% reduction from a baseline of mercury in coal combusted or output based emission standard of 0.008 pounds per gigawatt-hour. | filter (dry scrubbed units) submit plan by December 31, 2007, and implement plan by December 31, 2010. If two units owned, implementation at one by December 31, 2009. 2. For wet scrubbed units, plan required by December 31, 2009, and implemented by December 31, 2014. 3. The required mercury reduction level for each unit is fixed in a permit after completion of a start-up period and reflects emission monitoring and expected performance over the upcoming five-year period. | according to the schedule established in the CAMR – 2010 and 2018. |
| Trading Limitations | Trading not included. | No interstate trading. | No limitation. Compliance through regulation that follows EPA's model rule which allows participation in a national trading program. | No interstate trading. | Interstate trading allowed under a CAMR federal implementation plan. | No limitation. Compliance through regulation that follows EPA's model rule which allows participation in a national trading program. |
| Allowance Allocation or Emission Cap Methodology | Since CAMR vacated no allowances or emission cap related to the vacated CAMR. | Allowance allocations are not a feature of the Illinois mercury regulation. | 1. Indiana follows EPA's model rule. The only difference is a 1% set-aside of the annual state-wide mercury emission budget available to clean coal technology units for the years 2010 through 2021. 2. The heat input approach outlined in EPA's model rule is used | 1. In Michigan, affected units do not receive allocations. Instead annual mercury emission caps are established. 2. These emission caps are set by a procedure that ensures that the CAMR annual emission budget is not exceeded. 3. Annual determination and written notification | Minnesota is not proposing to submit a state plan to implement the CAMR therefore, allocation of allowances will be under a federal implementation plan and mirror EPA's model rule methodology. | 1. Ohio follows EPA's model rule. 2. The heat input approach outlined in EPA's model rule is used in their allocation methodology however, there is no adjustment for fuel type. 3. Retired units receive allowance allocations that do not sunset. |

| | Wisconsin | Illinois | Indiana | Michigan | Minnesota | Ohio |
|--------------------|---|---|--|--|---|------|
| | | | in their allocation methodology however, there is no adjustment for fuel type. 3. Retired units receive allowance allocations that do not sunset. | provided for the upcoming year with opportunity for appeal. 4. Highest three year heat input average from the most recent five year period. 5. Retired units do not receive an emission cap. | | |
| Flexibility | <p>1. Compliance must be demonstrated annually on a unit-by-unit basis. However, large units under common ownership or control can average to meet the mercury, nitrogen oxides (NOx) and sulfur dioxide (SO2) emission standards. Averaging can only occur among those units participating within the same compliance pathway.</p> <p>2. Under the multipollutant compliance pathway a 70% mercury removal from coal is established for 2015.</p> <p>3. An interim 80% mercury removal from coal is required by 2018</p> <p>4. Under the multipollutant compliance pathway, 90% mercury removal from coal combusted must be achieved by 2021.</p> <p>5. Early emission</p> | <p>1. A multipollutant approach is available as an alternative provided notice is given by December 31, 2007. This is a system-wide approach and once a commitment is made, opting out is not possible. Units planned for permanent shutdown can be exempted provided notice is received by June 30, 2009, and shutdown occurs within the next two years. There are emission standards for nitrogen oxides (NOx), sulfur dioxide (SO2) and mercury that each unit must achieve. Mercury control installation must occur between July 1, 2009, and December 31, 2014. Every unit must achieve compliance with the emission standard or reduction of mercury input standard beginning January 1, 2015.</p> <p>2. New power plants can</p> | | <p>1. Multipollutant proposal that achieves a minimum of 75% reduction on an affected unit may be substituted.</p> <p>2. Small units, less than 9 lbs. per year, may have an alternative plan.</p> <p>3. Technical or economic exception possible.</p> <p>4. Exceptional circumstances adjustment is available in 2016 and 2017.</p> | <p>1. Extension of deadlines allowed if necessary however, final compliance deadline cannot be extended more than 12 months.</p> <p>2. Power plants with wet scrubbed units can consider substitute units for control in lieu of a targeted unit.</p> | |

| | Wisconsin | Illinois | Indiana | Michigan | Minnesota | Ohio |
|---------------------------------|---|---|--|--|---|--|
| | reduction credits can be used to achieve the mercury reductions under the multipollutant pathway. | meet a temporary technology based standard until December 31, 2018, provided they are achieving Best Available Control Technology (BACT) for SO ₂ , NO _x and particulate matter (PM) and employ an approved mercury control technology. | | | | |
| Compliance Demonstration | Mercury emissions for compliance determined by monitoring, recordkeeping and reporting requirements in the CAMR. | Mercury emissions for compliance determined by monitoring, recordkeeping and reporting requirements in the CAMR. | Mercury emissions for compliance determined by monitoring, recordkeeping and reporting requirements in the CAMR. | 1. Mercury emissions for compliance determined by monitoring requirements in the CAMR. 2. Annual compliance demonstration plan beginning October 2009. 3. Annual and quarterly emission reporting required beginning April 2010. | Mercury emissions for compliance determined by monitoring, recordkeeping and reporting requirements in the CAMR. | Mercury emissions for compliance determined by monitoring, recordkeeping and reporting requirements in the CAMR. |
| Adopted or Proposed | Rule to be effective in 2008. | Rule effective December 2006. | Rule adopted October 2007. | Rule to be effective in 2008. | Mercury Emission Reduction Act of 2006 – Signed May 11, 2006 | Rule effective May 2007. |
| Additional Comments | 1. BACT proposals for small EGUs are required within 30 months of the effective date of the rule. 2. Large EGUs must identify whether they will follow the multipollutant compliance pathway within 24 months of the effective date of the rule. 3. The mercury reduction requirements and schedule will be reviewed in 2013. | | | 1. System-wide averaging or a multipollutant proposal can be disapproved if local mercury impacts a factor. 2. Units involved in a multipollutant proposal, subject to a small unit alternative or operating under a technical or economic exception cannot be involved in a system-wide average compliance approach. | 1. The Minnesota Pollution Control Agency reviews plans and makes recommendations to the Minnesota Public Utilities Commission which has approval authority. 2. Owners can recover costs for monitoring, control equipment, construction, operation and maintenance, relevant studies and other related costs incurred prior to plan | |

| | Wisconsin | Illinois | Indiana | Michigan | Minnesota | Ohio |
|---|--|--|--|---|--|--|
| | | | | 3. Mercury pretreatment credit available. | approval. 3. Multipollutant control proposals submitted with a mercury plan may also qualify for cost recovery. | |
| CAMR 1999 Baseline Emissions | 2,264 lbs. | 5,989 lbs. | 4,884 lbs. | 3,081 lbs. | 1,265 lbs. | 7,109 lbs. |
| CAMR 2010 – 2017 Emission Budget (% reduction) | 1,781 lbs. (21.4%) | 3,188 lbs. (46.8%) | 4,196 lbs. (14.1%) | 2,606 lbs. (15.4%) | 1,390 lbs. (+ 9.9%) | 4,114 lbs. (42.1%) |
| CAMR 2018 and thereafter Emission Budget (% reduction) | 702 lbs. (68.9%) | 1,258 lbs. (79.0%) | 1,656 lbs. (66.1%) | 1,028 lbs. (66.6%) | 550 lbs. (56.5%) | 1,624 lbs. (77.2%) |
| Coal Use Characterization for Electrical Energy Production – Data from Energy Information Administration | 2005 Coal Consumption for Electric Power – 24,615 (thousand short tons) 2005 Coal Received from Colorado, Montana and Wyoming for Electricity Generation – 22,493 (thousand short tons) | 2005 Coal Consumption for Electric Power – 53,822 (thousand short tons) 2005 Coal Received from Colorado, Montana and Wyoming for Electricity Generation – 45,699 (thousand short tons) | 2005 Coal Consumption for Electric Power – 60,011 (thousand short tons) 2005 Coal Received from Colorado, Montana and Wyoming for Electricity Generation – 11,843 (thousand short tons) | 2005 Coal Consumption for Electric Power – 36,273 (thousand short tons) 2005 Coal Received from Colorado, Montana and Wyoming for Electricity Generation – 28, 820 (thousand short tons) | 2005 Coal Consumption for Electric Power – 20,008 (thousand short tons) 2005 Coal Received from Colorado, Montana and Wyoming for Electricity Generation – 19,268 (thousand short tons) | 2005 Coal Consumption for Electric Power – 59,607 (thousand short tons) 2005 Coal Received from Colorado, Montana and Wyoming for Electricity Generation – 11,659 (thousand short tons) |
| | | | | | | |

**Mercury Emissions from Coal-fired
Power Plants
Public Health and Welfare Finding Pursuant to
Section 285.27(2)(b), Wisconsin Statutes**

ADDENDUM

June 17, 2008

**Wisconsin Department of Natural Resources
Bureau of Air Management**

Overview

In the absence of a federal standard promulgated under section 112 of the Clean Air Act, the Department may promulgate a standard if it finds that a standard is needed to provide adequate protection of public health and welfare. This is a statutory requirement, s. 285.27(2)(b), Wis. Stats., that necessitates written documentation to support a finding that addresses the following:

- Identify sources of mercury emissions and populations potentially at risk;
- Assess whether exposures to mercury are above a level of concern;
- Evaluate options to control risks from mercury emissions exposures;
- Compare mercury emission standards proposed with those from neighboring states.

A preliminary finding was prepared and offered for public review and comment along with proposed revisions to Chapter NR 446, Control of Mercury Emissions, Wis. Adm. Code. The March 2008 preliminary finding concluded that a state mercury standard for coal-fired power plants was appropriate based on scientific research and technical analyses of mercury emissions sources, exposures, health effects, control options and comparisons to standards in neighboring states. A public hearing was held in Madison on April 7, 2008 and written comments on the preliminary finding and the proposed rule were accepted until May 5, 2008.

This addendum provides additional analyses that responds to significant concerns on the preliminary finding raised in public comments.

Section 1 - What are the Stationary Sources of Mercury Emissions and Populations at Risk?

Preliminary Finding Summary

Wisconsin air emission inventory data indicates that three major types of stationary sources are responsible for mercury air emissions in the state:

1. Coal-fired electric generating units.
2. ERCO Worldwide chlor-alkali facility in Port Edwards.
3. Industrial coal-fired power boilers.

Coal-fired electric generating units in Wisconsin currently account for 62.5% of stationary source mercury emissions. After a planned conversion in 2010 to a mercury-free process at ERCO Worldwide, coal-fired electric generating units will account for 86% of total mercury air emissions from stationary sources. Establishing a mercury emission standard for coal-fired electric generating units to protect public health and welfare is the most effective option since these plants are the stationary sources that account for the majority of mercury air emissions in Wisconsin. Emission control technologies are commercially available to reduce mercury releases from the types of coal-fired electric generating units operating in Wisconsin. Additional technologies, suitable for commercial application, will be available within the next seven years.

The Wisconsin Department of Health and Family Services (DHFS), federal governmental organizations and institutions have identified women of child-bearing age, infants and children as the populations at greatest risk from elevated mercury exposure. A study of Wisconsin women estimated that about 6% of women who are childbearing age had elevated mercury levels. A survey conducted by the Wisconsin DHFS in 1999 found that more than 90% of Wisconsin women between the ages of 18 and 45 include fish in their diets and approximately one-third of them consume sport-caught fish.

Comment

Forest County Potawatomi Community expressed their concern that the preliminary finding did not recognize the additional risk that tribal members face. In their comments they state "Although DNR's findings already support the need for quick and dramatic mercury reductions, we strongly recommend that the DNR amend its findings to include the fact that people who eat above-average amounts of fish, such as Native Americans and members of other specific cultures, are at a particular risk from mercury emissions".

Response Summary

NATIVE AMERICAN POPULATIONS THAT CONSUME LARGE AMOUNTS OF FISH ARE AT GREATER RISK THAN THE POPULATION AS A WHOLE

Response Analysis

Native Americans in Wisconsin are a population that is at risk. In their written comments, the Forest County Potawatomi Community provide documentation supporting their interest in having the public health and welfare finding recognize Native Americans as a population in Wisconsin that is subject to an increased health risk. According to the U.S. Environmental Protection Agency (EPA 822-B-00-004, October 2000, [Methodology for Deriving Water Quality Criteria for the Protection of Public Health](#)), Native Americans have greater exposure because their fish consumption has been determined to be greater than the general population. As stated in EPA 822-B-00-004:

The default fish consumption value for the general adult population in the 2000 Human Health Methodology is 17.5 grams/day, which represents an estimate of the 90th percentile consumption rate for the U.S. adult population based on the U.S. Department of Agriculture's (USDA's) Continuing Survey of Food Intake by Individuals (CSFII) 1994-96 data (USDA, 1998). EPA will use this default intake rate with future national 304(a) criteria derivations or revisions. This default value is chosen to be protective of the majority of the general population.

However, States and authorized Tribes are urged to use a fish intake level derived from local data on fish consumption in place of this default value when deriving AWQC, ensuring that the fish intake level chosen is protective of highly exposed individuals in the population. EPA has provided default values for States and authorized Tribes that do not have adequate information on local or regional consumption patterns, based on numerous studies that EPA has reviewed on sport anglers and subsistence fishers. EPA's defaults for these population groups are estimates of their average consumption. EPA recommends a default of 17.5 grams/day for sport anglers as an approximation of their average consumption and 142.4 grams/day for subsistence fishers, which falls within the range of averages for this group.

The Forest County Potawatomi Community believe they are at even greater risk than EPA default data suggests because their members fish and are heavy fish consumers from lakes on or near their lands that have documented mercury contamination. In addition, they point out that several nearby lakes have been identified by the Department as having special mercury concerns including Deep Hole Lake and Little Sand Lake ([WDNR Special Advice for Mercury 2007](#)).

Comment

We Energies questioned whether valid estimates of the populations at risk in Wisconsin can be made from the available data.

Response Summary

6% OF WOMEN AND 16% OF MEN RESIDING IN WISCONSIN CONSUME ENOUGH FISH TO RESULT IN HAIR MERCURY LEVELS GREATER THAN 1 PPM

Response Analysis

To estimate the number of Wisconsin residents potentially affected, the Department of Health and Family Services' study combined fish consumption data from the 2004 Behavioral Risk Factor Survey, which is a statistically valid sample of Wisconsin's adult population, with hair mercury levels and fish intake data from a group of 2,038 volunteers to develop an estimate of mercury exposure among the general population. This process was used to avoid biases that can result from self-selection of hair donors who may be concerned about their mercury exposure. The estimate that 6% of women and 16% of men consume enough fish to have a hair mercury level greater than 1 ppm was derived by integrating data from the 2004 Behavioral Risk Factor Survey with data from the hair testing study.

Section 2 - Are Exposures Above a Level of Concern?

Preliminary Finding Summary

A 2004 - 2005 survey of mercury concentrations in hair in Wisconsin study volunteers showed that 29% of men and 13% of women had mercury levels above 1 part per million (ppm), which is the level of concern for adverse effects determined by United States Environmental Protection Agency (EPA). It is estimated that approximately 437,000 men and women in Wisconsin are exposed to mercury above the safe level established by the EPA. The health risks include developmental effects such as lower performance on language, attention and memory tests and adverse effects in vision and motor functions. Recent research has also identified mercury effects on the immune system and a potential role of mercury exposure in elevating the risks of heart attacks in adults. Health effects experts worldwide have identified the reduction of mercury exposures as a major public health goal.

Comment

We Energies expressed concern about the appropriate health benchmark and suggested that there is not sufficient scientific evidence to conclude that in addition to women, infants and children, the general public is also at risk of adverse effects from methylmercury levels currently found in some fish.

Response Summary

6% OF WOMEN AND 16% OF MEN RESIDING IN WISCONSIN CONSUME ENOUGH FISH TO RESULT IN HAIR MERCURY LEVELS GREATER THAN 1 PPM

Response Analysis

The following is a response from the state Department of Health of Health and Family Services (DHFS) related to this concern:

The Department of Health and Family Services believes there is sufficient evidence of a link between methylmercury and cardiovascular disease to take action to reduce mercury exposures in people of all ages and genders. Currently, the US EPA reference dose is the best benchmark we have to evaluate the health burden mercury contamination poses to the general public as well as to sensitive groups. The health department encourages people of all ages to eat fish that are low in mercury as part of a varied, healthy diet.

Comment

We Energies also questioned the health endpoint used by EPA and DHFS as well as the extrapolation method used to estimate affected Wisconsin populations.

Response Analysis

DHFS provided the following in response:

The Department of Health and Family Service recommends use of the EPA reference dose as the best available health guideline for mercury. In developing the reference dose, a single uncertainty factor of 10 was used to account for the lack of scientific study of the effects methylmercury may have on aging populations and on the immune and cardiovascular systems. Studies published by Salonen et al. 1995 and Grandjean et al. 2004 suggest that cardiovascular effects may occur at hair mercury levels as low as 2 to 4 ppm and that the current reference dose may provide a very narrow margin of safety.

Comment

We Energies commented that SO₄ deposition to Little Rock Lake in Vilas County declined by 45% during the 1994 to 2000 time period, possibly explaining the 30% decline in fish mercury.

We Energies commented that sulfate may play a more important role in mercury methylation and uptake in the fish population than mercury deposition.

Response Summary

REDUCTIONS IN MERCURY DEPOSITION WILL HAVE A GREATER EFFECT ON FISH CONTAMINATION THAN REDUCTIONS IN SULFATE

Response Analysis

Dr. Carl Watras, one of the authors of the article cited by We Energies, believes that this is a misinterpretation of the data and is uncertain where they derive the 45% estimate. His analysis of the mercury data from the National Atmospheric Deposition Program (NADP) for Wisconsin indicates that there is no statistically significant trend in SO₄ deposition over this time.

Dr. Watras provided the following concerning the role of atmospheric mercury deposition:

Research on lakes in Wisconsin and Canada demonstrates that reductions in mercury deposition will have a greater effect on fish contamination than reductions in sulfate. Studies on Little Rock Lake, Vilas County, show that changes in atmospheric mercury deposition have rapid effects on mercury concentrations in water and fish (Watras et al., 2000; Hrabik and Watras 2002). These studies indicate that new inputs of mercury are the major determinant of mercury contamination levels. The rapid incorporation of new mercury into aquatic food chains was confirmed recently by experimental additions of mercury isotopes to lakes in Canada (Paterson et al., 2006; Orihel et al, 2006; Harris et al., 2007). In contrast, reductions in sulfate deposition have a delayed effect rather than an immediate effect on mercury contamination. The delay results from the much longer half-life of sulfate compared to mercury in lake water (Urban and Monte, 2001; Watras et al., 2002). Thus, even though both mercury and sulfate co-mediate the production and bioaccumulation of methylmercury in sensitive Wisconsin lakes (e.g. Watras et al. 2006), the atmospheric deposition of mercury has the most immediate effect on contamination levels and public health.

Comment

We Energies commented that Common Loon reproduction may be harmed by factors other than mercury contamination of fish with other confounding factors playing a significant role in adverse effects on loon populations in Wisconsin.

Response Summary

MERCURY EXPOSURE IS A CRITICALLY IMPORTANT FACTOR THAT LIMITS LOON POPULATIONS

Response Analysis

Dr. Mike Meyer, Department researcher, has studied the effects of multiple stressors on loon populations and has evidence that mercury effects can be separated from these other stressors. He provided the following in response to the We Energies comment:

Common Loons have been found to have elevated Hg exposure when nesting on acidic lakes in Wisconsin, which is correlated with reduced productivity (Meyer et al. 1995, 1998). Mercury bioaccumulation impacts on loon populations are difficult to assess, due to confounding factors and the difficulty in measuring population dynamics in the field. Scientists in other regions have found habitat loss, water level fluctuations, predation and human disturbance to be associated with impacts on loon reproduction and survival. However, research in Wisconsin, New England, and the Canadian Maritimes has concluded that mercury exposure is a critically important factor that limits loon populations as well.

Recent findings measuring the relationship between brain neurochemistry and mercury exposure show that Common Loons are very sensitive to the toxicological effects of methylmercury, with ecologically relevant MeHg exposure levels associated with altered neurotransmitter concentrations (Scheuhammer et al. 2008). Scientists from USGS and WDNR (Kenow et al. 2003) dosed Common Loon chicks in captivity with fish containing MeHg (delivered in gelatin capsules) with concentrations bracketing and exceeding known loon prey Hg levels in North America. The experiment was conducted for 105 days post-hatch. No overt toxicity or reduction in growth rates were observed at any dose (Kenow et al., 2003) but evidence of reduced immune function and central nervous tissue demyelization was found when chicks were fed fish containing 0.4 ug/g (wet weight) or more MeHg (Kenow et al., 2007a; 2007b). Mercury-associated effects related to oxidative stress and altered glutathione metabolism occurred at 1.2 µg Hg/g and 0.4 µg Hg/g, an ecologically-relevant dietary mercury level, but not at 0.08 µg Hg/g (Kenow et al. in press).

Common Loon MeHg egg injection studies currently underway in Wisconsin are designed to establish the level of MeHg in loon eggs associated with reduced hatching rates, as well as the blood Hg concentrations of females producing eggs with comparable concentrations. These experiments have demonstrated that hatchability is reduced >40% when egg MeHg exceeds 1.3 ug/g wet weight, a level of MeHg found in Wisconsin loon eggs (Kenow et al. ms. in prep).

Studies comparing Canadian versus Wisconsin loon populations have identified mercury as an important stressor that is currently limiting loon production in Wisconsin (Burgess and Meyer 2008). Environment Canada and Wisconsin DNR scientists measured lake pH, mercury (Hg) concentrations in small fish, blood Hg levels in adult male, female and juvenile common loons, and loon productivity from 120 lakes in Wisconsin, USA and New Brunswick and Nova Scotia, Canada (Maritimes). Blood Hg concentrations in adult and juvenile loons decreased with lake pH and increased with Hg levels in fish prey. Loon Hg exposure, measured either as Hg levels in female loon blood or in fish prey, appeared to impose an upper limit on loon productivity. Loon productivity decreased as Hg exposure increased. Quantile regression analysis indicated that maximum observed loon productivity dropped 50% when fish Hg levels were 0.21 ug/g (wet wt), and failed completely when fish Hg concentrations were 0.41 ug/g. Loon prey MeHg concentrations frequently exceed 0.21 ug/g (wet wt.) on acidic lakes in Wisconsin.

A loon mercury population level risk assessment is currently underway in Wisconsin and New England, funded by USEPA STAR Cooperative Agreement R82-9085. We used recent developments in theoretical population ecology to construct basic models of loon demography and population dynamics. Parameterization of these models is made possible by bird banding studies and the long-running commitments monitoring of loon productivity. Our models include deterministic, two-stage, density independent matrix models yielding population growth rate estimates of 0.99 and 1.01 for intensively studied populations in Wisconsin and New Hampshire (Grear et al. in review). Preliminary model simulations indicate that reductions of Hg in fish in acidic lakes in Wisconsin can result in an improvement in the annual growth rate of the loon population in Wisconsin of approximately 1% (Meyer 2006).

It is essential that mercury emissions and mercury deposition from Wisconsin sources be reduced to the maximum extent feasible, to reduce the stressor of methylmercury, which can impair the reproduction of fish-eating wildlife, such as the Common Loon.

Comment

We Energies provided comments critical of the preliminary public health and welfare finding that a mercury emission standard for coal-fired power plants in Wisconsin is necessary.

We Energies references mercury modeling studies in their comments that they believe demonstrate that mercury emissions from coal-fired power plants are insignificant contributors to mercury contamination in Wisconsin. Their objection is expressed in the preface to their comments:

Overall we disagree with the finding that “a revised mercury emission standard for coal-fired [electric generating units] EGUs is necessary to protect public health and welfare from mercury exposure”. This conclusion is not supported by any of the referenced studies. DNR’s Finding fails to address, let alone answer, the crucial question: Are Wisconsin coal-fired power plants the sources of mercury to which Wisconsin residents are exposed?

In their comments on the preliminary finding, We Energies challenged this statement:

The State of Michigan estimates that emissions from coal-fired power plants comprise 50% Hg0, 30% RGM and 20% HgP, which implies that about half of the emitted mercury is readily deposited (Sills et al., 2007). However, a recent study shows that Hg0 undergoes atmospheric reactions that convert it to RGM and/or HgP enhancing the tendency for local and regional deposition (Lindberg et al., 2007).

WE Energies cited the June 2007 modeling study prepared by Atmospheric & Environmental Research, Inc. (AER) using the Trace Element Analysis Model (TEAM) that found less than 5% of mercury deposited in Wisconsin was caused by emissions from Wisconsin coal-fired power plants. They also noted the opinion of Dr. O. Russell Bullock, Meteorologist with the Atmospheric Model Development Branch of the National Oceanic and Atmospheric Administration, who provided his opinion at the Natural Resources Board Mercury Seminar in July 2007 that less than 10% of mercury deposition in the contiguous U.S. is from domestic coal-fired utility boilers. Dr. Bullock uses EPA’s CMAQ (Community Multiscale Air Quality) model in support of his mercury deposition estimation

Response Summary

THERE IS SUFFICIENT EVIDENCE TO CONCLUDE THAT A CONTROL STANDARD FOR MERCURY REDUCES MERCURY DEPOSITION FROM COAL-FIRED ELECTRIC GENERATING UNITS IN THE STATE

Response Analysis

Mercury exists in the atmosphere in three basic forms, reactive gaseous mercury (RGM), elemental mercury (Hg0) and particle-bound mercury (HgP). All three species are subject to:

1. Atmospheric reactions with other pollutants such as ozone,
2. Dry deposition as the mercury species come in contact with surfaces,
3. Wet deposition as mercury is incorporated into rain, fog or snow.

In the preliminary public health and welfare finding, the contribution of mercury deposition in Wisconsin by mercury emissions from our coal-fired power plants was determined to be significant enough to warrant regulation. That determination was based in part on the following:

The State of Michigan estimates that emissions from coal-fired power plants comprise 50% Hg₀, 30% RGM and 20% Hg_P, which implies that about half of the emitted mercury is readily deposited (Sills et al., 2007). However, a recent study shows that Hg₀ undergoes atmospheric reactions that convert it to RGM and/or Hg_P enhancing the tendency for local and regional deposition (Lindberg et al., 2007).

Some models used to simulate mercury transport and transformation are called chemical transport models including AER's TEAM model and Total Risk of Utility Emissions (TRUE) model and Environ's Comprehensive Air quality Model with extensions (CAMx), and EPA's CMAQ model. These chemical transport models employ different mathematical techniques to simulate the transport of mercury, the chemical transformations of mercury and other chemical species, the physics of deposition, and meteorological parameters such as rainfall. Much uncertainty exists in these key modeling parameters that govern most of the chemical and physical properties of the mercury species simulated in chemical transport models. Since atmospheric mercury modeling is relatively new and extremely complex, there is a significant degree of uncertainty in model findings. Furthermore, it is very difficult to measure mercury species and trace mercury reactions at typical atmospheric concentrations, so there is little or no real world verification of many critical atmospheric processes that influence mercury deposition. Modeling studies are important but should not be relied upon to be the only data considered when evaluating mercury deposition from local sources.

Observation based models are a powerful check on the chemical transport models. Observation based models employ actual measurements to establish a relationship between emissions and pollutant concentrations. This helps to overcome the inherent weakness in mercury emission estimates used in chemical transport models. Rutter, *et. al.* applied an observation based model to evaluate the impact on mercury concentrations in Wisconsin from local point sources.

The following is a summary of additional analyses that leads to the conclusion that a control standard for mercury reduces mercury deposition from coal-fired electric generating units in the state:

- Historic chemical transport modeling studies have underestimated the contribution from local sources due to an underestimation of dry deposition rates and other modeling problems.
- The atmospheric mercury cycle is more dynamic than previously thought, with short residence times perhaps on the order of hours to days. Therefore, emitted mercury may not travel far from a source before being deposited onto forest vegetation, soils or surface waters (Gustin *et. al.*, 2008).
- Evaluation of ambient mercury measurements cast significant doubt on the hypothesis that an overwhelming amount of the mercury deposition in Wisconsin can be attributed to global or regional sources.

- Recent research (Rutter, *et. al.*, 2008), using ambient mercury measurements, demonstrated that local mercury point sources contributed 63% to the reactive gaseous mercury concentration in Milwaukee and 48% at Devil's Lake State Park, Sauk County.
- Recent research, such as Manolopoulos, *et. al.*, 2008, demonstrates there is a significant local point source contribution to reactive gaseous mercury concentrations in Wisconsin.
- Eight to 10% is the lower bound for what could be expected for contribution to mercury deposition in Wisconsin from the state's coal-fired power plants.

More detail is provided below.

1. Historic mercury deposition modeling studies underestimate the impact of local sources.

The AER models, TEAM and TRUE, and other models using the same deposition algorithms and model configurations, have two major weaknesses that systematically underestimate the contribution of local sources to mercury deposition.

The first weakness concerns dry deposition velocity. In the AER models, the dry deposition velocities for both divalent and elemental mercury are substantially less than estimates used in EPA's CMAQ model. In the AER models, a single estimate of 0.5 cm/s (centimeters per second) for the dry deposition velocity for divalent mercury, is a factor of 3 to 5 less than the estimates in CMAQ for Wisconsin. Similarly, the AER models single estimate of 0.01 cm/s for the dry deposition velocity of elemental mercury is also a factor of 3 to 5 less than the estimates in CMAQ for Wisconsin. The net result of the underestimation of dry deposition velocity is an underestimate of local source contribution to mercury deposition and an overestimation of mercury deposition due to distant sources.

The second weakness concerns the assumption for the top boundary of the atmosphere in the model. The AER models cap the top of the modeling domain at 7 Km (kilometers). The Department's mercury modeling study (*Development of an Atmospheric Mercury Modeling System for the Great Lakes Region*) and the report from Environ (*Modeling Atmospheric Mercury Chemistry and Deposition with CAMx for a 2002 Annual Simulation*) indicate that the top boundary assumption is critical and can be an overwhelming factor in determining wet deposition estimates. Environ recommended that the top boundary be set at the bottom of the stratosphere, much higher than 7 Km. When the Department implemented this change in their modeling study, it significantly improved model performance. The net result of using the 7 Km height for the top boundary condition is likely an overestimate of the percentage contribution from distant sources and an underestimate of the percentage contribution from local sources.

In addition to these inherent model weaknesses, the Department's analysis of event sampling data at Devils Lake State Park indicates that a significant portion of annual mercury deposition may fall during relatively short term events, such as summertime thunderstorms. To date, most mercury modeling studies like the AER models use a large grid structure that does not properly consider mercury deposition during thunderstorms. Intense precipitation events are effective at scavenging divalent mercury, leaving little atmospheric mercury for long range transport. The net result of sacrificing grid structure for computational efficiency

may be an underestimation of the local source contribution to wet mercury deposition and an overestimation of the contribution to wet mercury deposition from distant sources

2. Fate of Mercury in the Environment

Early studies of atmospheric mercury suggested that it remained in the atmosphere for about one year, the estimated time needed to attain a relatively uniform air concentration (~2ng Hg/m³) across the northern hemisphere (Lindqvist, 1985; Fitzgerald, 1989). Such long residence times implied that emitted mercury was transported far away from sources. However, more recent studies indicate that the atmospheric mercury cycle is more dynamic than previously thought, with short residence times perhaps on the order of hours to days (Gustin et al., 2008). These studies imply that emitted mercury may not travel far from a source before being deposited onto forest vegetation, soils or surface waters. Such rapid removal of mercury from air is not simply a function of chemical speciation in stack gases, but it also depends upon reactions that occur in the atmosphere during transport as well as reactions that occur on impacted surfaces.

Re-emission of newly deposited mercury on daily time scales can result in a “multi-hop” phenomenon, so that the behavior of atmospheric mercury has been compared to a ping-pong ball bouncing on a stone floor with patches of soft carpet (Hegdecock and Pirrone, 2004; Jernelov, 2000). Rapid exchanges of mercury between air and earth surfaces may give the appearance of homogeneous air concentrations, explaining the over-estimation of residence times in early studies (Gustin et al., 2008). In studies of our sensitive Wisconsin lakes, data indicate that most of the mercury which enters the lakes stays in the lakes – behaving, metaphorically, as “soft carpet patches” (Watras et al., 1994).

3. Sulfate as a Mercury Tracer

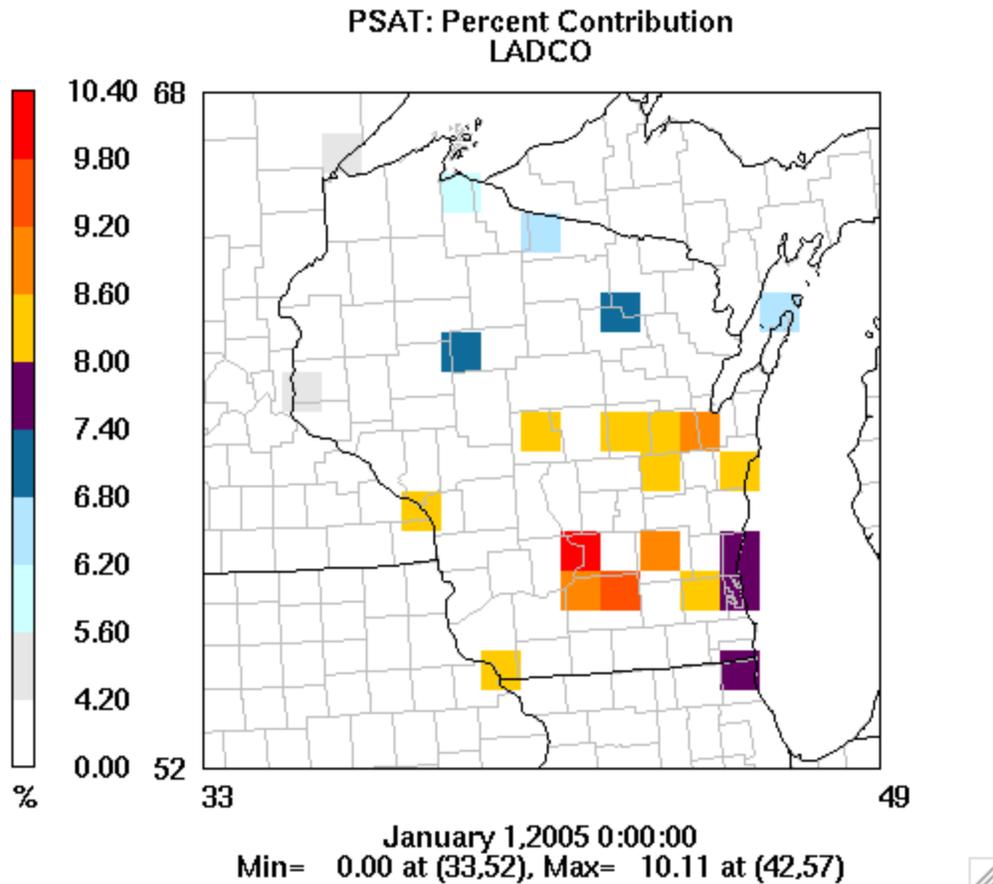
Due to the significant uncertainties surrounding the accuracy of atmospheric mercury modeling, the Department, in conjunction with the Lake Michigan Air Directors Consortium (LADCO), used another approach to assess mercury deposition from Wisconsin sources. The technique involves approximating the contribution of Wisconsin power plants to mercury deposition using sulfate as a tracer for mercury. The technique works, because 1) power plants are the principal source of mercury and sulfate ion in Wisconsin, 2) the CAMx model performs very well at simulating sulfate concentrations, and 3) the PSAT algorithm in CAMx allows one to trace sulfate back to its source.

The modeling results, presented in Figure 1 below, show that Wisconsin power plants are responsible for approximately 6 to 10% of the annual sulfate ion concentration at fine particle monitoring sites in the state.

Although sulfate is subject to deposition, ammonium sulfate particles are not as readily deposited as is mercury in the reactive gaseous form. Therefore, a 6 to 10% estimate of mercury deposition from Wisconsin’s coal-fired power plants would be a lower bound of the expected mercury deposition. In any event, wet deposition of mercury from Wisconsin’s coal-fired power plants is likely to be much larger than the 1 or 2 % contribution postulated in stakeholder comments on the proposed mercury rule.

Figure 1

Wisconsin EGU Contribution: SO4



4. Local Deposition Assessment from the National Mercury Deposition Network

A comparison of Mercury Deposition Network (MDN) data indicates marked differences in annual average mercury concentration and mercury deposition rates in different geographic regions of the U.S. Areas in the rural locations in the northeastern U.S. have long-term average mercury deposition rates that are about half of those in many rural Wisconsin locations, but on average, the northeastern U.S. locations receive from 5 to 20 more inches of precipitation in a year. A possible explanation is that coal used for electric power generation in Wisconsin and the Midwest contributes to higher deposition rates in Wisconsin and the lower deposition rates in the Northeast result from the predominate use of oil for electric power generation in that area of the U.S.

In addition, national MDN data indicates significant regional and site-specific differences in mercury deposition trends in the eastern half of the U.S. These regional differences occur despite the fact that MDN sites are typically in rural areas in an attempt to limit the effects of local sources on the monitors. It is very likely that the differences in deposition are a result of strong influence of local and regional emission sources on measured wet deposition (TJ Butler *et. al.*, 2008).

Electric utility representatives have postulated that mercury deposition in the U.S. is dominated by the contribution from global sources and that mercury emissions from sources outside North America are increasing. However, the fact that mercury deposition in the eastern U.S. was found to be gradually declining in a recent research paper (TJ Butler *et. al.*, 2008) contradicts a hypothesis that global mercury dominates deposition in the U.S.

5. Recent Research - Ambient Measurements of Mercury in Wisconsin

Recently published research (Rutter *et al.*, 2008) indicates that point sources in Wisconsin and neighboring states significantly impact measured concentrations of mercury species at two measurement locations in Wisconsin. Researchers at the University of Wisconsin - Madison performed measurements of gaseous elemental mercury (Hg₀), particulate mercury (HgP), and divalent mercury, also known as reactive gas mercury (RGM). The scientists identified regional and local mercury source regions and calculated an estimate of source impacts on atmospheric concentrations of elemental and reactive species at Devil's Lake State Park and Milwaukee.

Point sources were determined to impact concentrations at the monitoring sites by virtue of short, episodic increases in mercury species that were too large and irregular to be explained by photochemistry or contributions from natural sources. When mercury concentrations exceeded 3 times the standard deviation of the reference mean, the values were interpreted as discrete periods when anthropogenic point sources were directly impacting the monitoring site.

Pollution roses of elevated mercury concentrations were constructed for each location (Supplement). Frequent, elevated mercury concentrations were caused by point sources in Milwaukee and Kenosha counties in Wisconsin, as well as some counties in Illinois, Indiana and Michigan. Devil's Lake State Park was impacted by point sources located in the counties to the southeast (Columbia, WI; Milwaukee, WI; Cook; IL, Du Page IL; Will, IL), southwest (Grant, WI; Linn, IA) and west (Vernon, WI; Allamakee, IA.).

The research demonstrates that point sources within tens of kilometers downwind of both monitoring sites strongly influence mercury measurements. Importantly, the research team determined the point source contribution to reactive mercury (RM), the sum of HgP and RGM, is 48% at Devil's Lake State Park and 64% at Milwaukee (Table 1).

Table 1 - Contributions of Point and Area Sources to Annual Average Hg₀ and RM Concentrations at Devil's Lake State Park and Milwaukee, Wisconsin

| | Devil's Lake State Park | | | | | Milwaukee | | | | |
|--------------------------------------|-------------------------|--------------------------|----|---------------|----|----------------------|---------------------------|----|---------------|----|
| | Annual Average Conc. | Area ^a Source | % | Point Sources | % | Annual Average Conc. | Area ^a Sources | % | Point Sources | % |
| Hg ₀ (ng/m ³) | 1.62 | 1.58 | 98 | 0.04 | 2 | 2.48 | 1.67 | 67 | 0.81 | 33 |
| RM (pg/m ³) | 11.8 | 6.0 | 52 | 5.7 | 48 | 21.7 | 7.9 | 36 | 13.8 | 64 |

(a) Area sources are the sum of all of the other mercury sources contributing to the monitored concentration, other than the mercury concentration attributed to the discrete point sources.

In a related study, (Manolopoulos, 2008 *et. al.*), researchers made ambient mercury measurements concurrently at two rural locations in southern Wisconsin. The researchers measured atmospheric elemental mercury, divalent mercury, and particulate mercury (HgP) concentrations from April through September 2003 at Mt. Horeb in Dane County and Devil's Lake State Park which are located approximately 40 miles apart. Sulfur dioxide was also monitored at Devil's Lake State Park.

The researchers observed frequent, significant peaks in divalent mercury concentration at Devil's Lake State Park that coincided with peaks in SO₂ concentrations. These measurements are indicative of point source plume impacts. Similar contemporaneous peaks were not noted at Mt. Horeb. The authors concluded that the marked difference in divalent mercury concentrations indicate that the source(s) of divalent mercury to each site was local.

The researchers identified five events where divalent mercury spikes (concentrations exceeding 75 pg/m³ at Devil's Lake State Park) were coincidental with significant increases in SO₂. The similar behavior between SO₂ and divalent mercury suggests that the same source emitted both species. Gaussian plume dispersion modeling and meteorological data identified the SO₂ emission source to be a coal-fired power plant in Columbia County.

Section 3 - What are the Options to Control Risks from Mercury Emission Exposures?

Preliminary Finding Summary

Developing a revised emission standard for coal-fired electric generating units to protect public health under the provisions of s. 285.27(2)(b) Wis. Stats. is the most appropriate option to achieve significant mercury emission reductions from stationary sources since coal-fired electric generating units are the stationary source category that accounts for the majority of mercury emissions in Wisconsin.

The costs of mercury control technologies applicable to coal-fired electric generating units found in Wisconsin are reasonable and cost-effective in comparison to the costs to control conventional pollutants from this stationary source category, including particulate matter, nitrogen oxides and sulfur dioxide. Multipollutant approaches are preferred because environmental and public health benefits can be achieved at lower costs.

The costs of mercury control technology applicable to coal-fired electric generating units in Wisconsin are reasonable and cost-effective. Technologies are commercially available and are capable of achieving 90% reduction. For example, the cost of sorbent injection with existing particulate control equipment is expected to range from 0.04 to 0.15 cents per kilowatt hour for all electric generating unit sizes and a Toxecon® system costs in the range of 0.12 to 0.24 cents per kilowatt hour for large electric generating units with both approaches achieving 90% mercury removal. Similar control efficiencies can be achieved at lower cost when mercury control is integrated into a multipollutant control system. The mercury portion of multipollutant control costs could be as low as 0.04 to 0.1 cents per kilowatt hour, while achieving mercury removal efficiencies in the range of 80% to 95%.

Comment

Wisconsin electric utilities are concerned that mercury control technologies appropriate for their coal-fired electric generating units are not commercially available and that mercury control technologies under development may not be able to achieve a high level of reductions.

The rule's 90% emission reduction requirement will be a technology challenge, and the costs associated with this high level of emissions reduction are not known with certainty at this time - We Energies.

WPL will try to achieve 90% mercury reduction, but believes it is only realistic to propose such limits when there is long-term actual operational experience to support this level of stringency - Wisconsin Power & Light Company.

Response Summary

EFFECTIVE MERCURY CONTROL TECHNOLOGY WILL BE AVAILABLE TO MEET THE PROPOSED RULE REVISIONS

Response Analysis

The March 2008 Preliminary Public Health and Welfare Finding identified the nature of Wisconsin's utility electric generating sector, the challenges to achieving mercury emission reductions from coal-fired electric generating units and the approaches that can lead to significant mercury emission reductions at reasonable costs. The mercury control

requirements being proposed in Chapter NR 446, Control of Mercury Emissions, Wis. Adm. Code, reflect the evaluation in the preliminary finding.

In Wisconsin, electrical energy is primarily provided by coal combustion and the principal coal types used are subbituminous and bituminous. Subbituminous coal firing accounts for 84% of our coal-fired electric generating capacity. As outlined in the preliminary finding, a critical issue for many of the electric utilities is the affect of activated carbon on the reuse of fly ash as a concrete additive. The type of coal combusted also has an effect on the suitability of fly ash for reuse. Fly ash from bituminous coal-fired electric generating units typically does not have the right chemical characteristics for use as a cement additive.

Activated carbon is a commercially available mercury control technology and capable of achieving removal efficiencies of 90% or greater. However, activated carbon, makes the fly ash unusable as a concrete additive. As a result, fly ash contaminated with activated carbon would require placement in a landfill if another recycling option was not available. Activated carbon is still an important mercury control approach that can be applied in situations where fly ash recycling is not a consideration. A specially formulated activated carbon sorbent, C-PAC® is available that is concrete friendly and capable of 90% mercury reductions. Regardless, in all cases a Toxecon® system can be used to avoid fly ash reuse impacts. However, this approach is typically reserved for large coal-fired electric generating units.

For the large coal-fired electric generating units in the state, mercury control technologies that do not contaminate fly ash and can be integrated with multipollutant control systems are currently planned or being considered for installation. These mercury control technologies have been demonstrated to be effective or are on a development path that will allow them to be commercially available within the compliance schedule and capable of meeting the mercury emission limitations being proposed under the multipollutant option.

Comment

Wisconsin electric utilities are concerned that the costs for suitable mercury control technologies cannot be estimated at this time and may be substantial.

Response Summary

MERCURY CONTROL TECHNOLOGY COSTS ARE REASONABLE IN COMPARISON TO CRITERIA POLLUTANT CONTROL TECHNOLOGY COSTS PARTICULARLY IF A MULTIPOLLUTANT CONTROL APPROACH IS PURSUED

Response Analysis

The cost of mercury control technology applicable to coal-fired electric generating units in Wisconsin are reasonable and cost-effective. These technologies, including sorbent injection with a Toxecon® system or with existing particulate control equipment, are commercially available and are capable of achieving 90% reduction. Similar control efficiencies can be achieved at lower cost when mercury control is integrated into a multipollutant control systems. Multipollutant approaches are preferred because additional environmental and public health benefits can be achieved at lower costs. It is a opportune time to consider a multipollutant approach to reducing mercury since most of the electric utilities in Wisconsin are currently in the process of planning and installing equipment to control other pollutants.

Section 4 - What are Neighboring States Doing to Address Mercury Emissions from Coal-fired Electric Generating Units?

Preliminary Finding Summary

Among neighboring states, Illinois, Michigan and Minnesota are proposing or have adopted requirements more stringent than Wisconsin's current rule. Under the proposed rule, Wisconsin, like Illinois, Michigan and Minnesota, is requiring large electric generating units to achieve a 90% reduction based on mercury in coal combusted. Dates by which compliance with this mercury emission standard is required varies from 2009 to 2021. In part, this variation can be attributed to the availability of multipollutant reduction options that extend the mercury reduction compliance date in exchange for reductions in sulfur dioxide and nitrogen oxides. Wisconsin, like Illinois and Michigan, will include mercury emission standards for new coal-fired electric generating units.

Finding

THE PROPOSED RULE REVISIONS CONSIDERS THE SITUATION IN WISCONSIN AND ARE COMPARABLE TO REQUIREMENTS IN OUR NEIGHBORING STATES

Comment

Wisconsin electric utilities have emphasized that the approaches taken to achieve mercury emission reductions in neighboring states were developed to take into account their unique situations and include provisions in their requirements that reflect those situations. Environmental organizations are concerned that the mercury reduction levels and schedules they prefer and that are being implemented in our neighboring states are not reflected in the mercury control standard being proposed.

Analysis and Response

Wisconsin, like Illinois, Michigan and Minnesota, is proposing to require coal-fired electric generating units to achieve a 90% reduction based on mercury in coal combusted. Compliance deadlines with this 90 % mercury emission standard in these state requirements varies from 2009 to 2021. In part this variation can be attributed to the availability of multipollutant reduction options that extend the mercury reduction compliance date in exchange for reductions in sulfur dioxide and nitrogen oxide. Each of these four states has built-in to their requirements compliance flexibility such as emission averaging and less restrictive requirements for smaller electric generating units.

Illinois, Michigan, and Wisconsin have included specific mercury emission standards for new coal-fired EGUs or power plants.

Illinois, Michigan and Minnesota all have law or regulations that require a 90% reduction based on mercury in coal combusted. Michigan requires compliance by January 1, 2015. Illinois requires compliance with their mercury emission standard by July 1, 2009 and Minnesota established a compliance date of December 31, 2010 or December 31, 2014 depending upon the type of sulfur dioxide or nitrogen oxide emission control system being used.

In Indiana and Ohio there are no specific mercury reduction requirements for coal-fired electric generating units. These states developed regulations to meet the now vacated federal CAMR through participation in EPA's national trading program.

Averaging can be used to demonstrate compliance with the 90% mercury emission standard in Illinois until December 31, 2013 provided that each unit achieves a 75% reduction of mercury in coal combusted. An individual unit or multiple units may demonstrate compliance with the Illinois mercury emission standard by demonstrating that actual emissions are less than allowable emissions over a rolling 12-month period.

In Michigan, compliance can be demonstrated unit-by-unit, power plant-wide or system-wide at the choice of an owner or operator. The compliance approach can also change from year-to-year at the owner or operators discretion with advance notification. Small coal-fired EGUs, with mercury emissions less than 9 pounds per year, can propose an alternative reduction plan. Technical or economic exceptions to the mercury emission standard may also be provided.

Minnesota allows up to a 12-month extension to their compliance dates and units that are equipped with wet scrubbers to reduce sulfur dioxide emissions can substitute a different unit for a targeted unit in their mercury control law.

Under the Wisconsin rule proposal, coal-fired EGUs under common ownership or control may average to achieve the proposed mercury emission standard or multipollutant requirements for sulfur dioxide and nitrogen oxide.

References

Section 1

RISK TO NATIVE AMERICAN POPULATIONS

[Methodology for Deriving Water Quality Criteria for the Protection of Public Health](#), United States Environmental Protection Agency, Office of Water & Office of Science and Technology, EPA 822-B-00-004, October 2000.

[WDNR Special Advice for Mercury 2007](#)

ESTIMATING THE NUMBER OF WISCONSIN RESIDENTS POTENTIALLY AFFECTED

Salonen, et al. Intake of Mercury from Fish, Lipid Peroxidation, and the Risk of Myocardial Infarction and Coronary Cardiovascular, and Any Death in Eastern Finnish Men. *Circulation*. 1995; 91:645-655.

Grandjean P, Murata K, Budtz-Jorgensen E, Weihe P. 2004. Cardiac autonomic activity in methylmercury neurotoxicity: 14-year follow-up of a Faroese birth cohort. *J Pediatr*. 144:169-76.

Section 2

HEALTH BENCHMARK

Salonen, et al. Intake of Mercury from Fish, Lipid Peroxidation, and the Risk of Myocardial Infarction and Coronary Cardiovascular, and Any Death in Eastern Finnish Men. *Circulation*. 1995; 91:645-655.

Grandjean P, Murata K, Budtz-Jorgensen E, Weihe P. 2004. Cardiac autonomic activity in methylmercury neurotoxicity: 14-year follow-up of a Faroese birth cohort. *J Pediatr*. 144:169-76.

REDUCTIONS IN MERCURY COMPARED TO SULFATE REDUCTIONS

Harris, R., Rudd, J.W.M., Amyot, M. and others. 2007. Whole-ecosystem study shows rapid fish-mercury response to changes in mercury deposition. *Proceedings of the National Academy of Sciences* **104**(42): 16586-16591.

Hrabik T. R. and Watras, C.J. 2002. Recent declines in mercury concentrations in a freshwater fishery: isolating the effects of de-acidification and decreased atmospheric mercury deposition in Little Rock Lake. *Sci. Total Environ* 297:229-237.

Orihel, D.M., Paterson, M.J., Gilmour, C.C., Bodaly, R.A., Blanchfield, P.J., Hintelmann, H., Harris, R. and Rudd, J.W.M. 2006. Effect of loading rate on the fate of mercury in littoral mesocosms. *Environmental Science and Technology* **40**(19): 5992-6000.

Paterson, M.J., Blanchfield, P.J., Podemski, C., Hintelmann, H., Gilmour, C.C., Harris, R., Ogrinc, N., Rudd, J.W.M. and Sandiland, K.A. 2006. Bioaccumulation of newly deposited mercury by fish and invertebrates: an enclosure study using mercury isotopes. *Can. J. Fish. Aquat. Sci.* **63**: 2213-2224.

Urban, N.R. and Monte, A.E. 2001. Sulfur burial and loss from the sediments of Little Rock Lake, Wisconsin. *Can. J. Fish. Aquat. Sci.* **58**: 1347-1355.

Watras, C.J., Morrison, K.A., Hudson, R.J.M., Frost, T.M. and Kratz, T.K. 2000. Decreasing mercury in northern Wisconsin: Temporal patterns in bulk precipitation and a precipitation-dominated lake. *Environ. Sci. Tech.* 34(19): 4051-4057.

Watras, C.J., Morrison, K.A. and Kratz, T.K. 2002. Seasonal enrichment and depletion of Hg and SO₄ in Little Rock Lake: relationship to seasonal changes in atmospheric deposition. *Can. J. Fish. Aquat. Sci.* **59**: 1660-1667.

COMMON LOON REPRODUCTIVE SUCCESS

Burgess, N.M. and Meyer, MW. 2008. Methylmercury exposure associated with reduced productivity in common loons. *Ecotoxicology* 17(2): 83-91.

Grear, JW, Meyer, MW, Cooley, JH, Kuhn, A, Piper, WH, Mitro, MG, Vogel, HS. (In review) Population growth and demography of a long-lived piscivorous bird in lakes of the northern United States. *Journal of Wildlife Management*.

Kenow, K.P., Gutreuter, S., Hines, R.K., Meyer, M.W., Fournier, F., Karasov, W.H. (2003). Effects of methyl mercury exposure on the growth of juvenile common loons. *Ecotoxicology* 12 171-182.

Kenow, KP, Grasman, KA, Hines, RK, Meyer, MW, Gendron-Fitzpatrick, A, Spalding, M, Gray, BR. 2007. Effects of methylmercury exposure on the immune function of juvenile common loons. *Environmental Toxicology and Chemistry* 26: 1460-1469.

Kenow, KP, Meyer, MW, Hines, RK, Karasov, WH. 2007. Distribution and accumulation of mercury in tissues and organs of captive-reared common loon (*Gavia immer*) chicks. *Environmental Toxicology and Chemistry* 26(5)1047–1055.

Kenow, KP, Hoffman, DJ, Hines, RK, Meyer, MW, Bickham, JW, Matson, KW, Stebbins, KR, Montagu, P, and Elfessi, A. (In Press). Effects of methylmercury exposure on glutathione metabolism, oxidative stress, and chromosomal damage in captive-reared common loon (*Gavia immer*) chicks.

Meyer, MW. 2006. Evaluating the Impact of Multiple Stressors on Common Loon Population Demographics - An Integrated Laboratory and Field Approach. USEPA STAR Grant R82-9085, Final Report. July 31, 2006.

Meyer, M.W., D.C. Evers, J.J. Hartigan, P.W. Rasmussen. 1998. Patterns of common loon (*Gavia immer*) mercury exposure, reproduction, and survival in Wisconsin. *Env. Toxicol. Chem.* 17(2) 184-190.

Meyer, M.W., D. Evers, and T. Daulton. 1995. Common loons nesting on acidified lakes in northern Wisconsin have elevated mercury exposure. *Water, Air, and Soil Pollution* 80: 871-880

Scheuhammer, AM, Basu, N, Burgess, NM, Elliott, JE, Campbell, GD, Wayland, M, Champoux, L, Rodrigue, J. 2008. Relationships among mercury, selenium, and neurochemical parameters in common loons (*Gavia immer*) and bald eagles (*Haliaeetus leucocephalus*). *Ecotoxicology* (2008) 17:93–101.

MODEL UNDERESTIMATION OF LOCAL MERCURY SOURCE IMPACT

Wisconsin DNR, Development of an Atmospheric Mercury Modeling System for the Great Lakes Region, Final Report to the United States Environmental Protection Agency, Grant No. X97579601, June 23, 2004.

Greg Yarwood, Steven Lau, Yiqin Jia, and Prakash Karamchandani, November 2003, Final Report, Modeling Atmospheric Mercury Chemistry and Deposition with CAMx for a 2002 Annual Simulation, Prepared for Wisconsin Department of Natural Resources, ENVIRON International Corporation.

FATE OF MERCURY IN THE ENVIRONMENT

Fitzgerald, W.F. 1989. Atmospheric and Oceanic Cycling of Mercury. *In* Chemical Oceanography Series. Edited by J.P. Riley and R. Chester. Academic Press. pp. 151-186.

Gustin, M.S., Lindberg, S.E., and Weisberg, P.J. 2008. An update on the natural sources and sinks of atmospheric mercury. *Applied Geochemistry* 23: 482-493.

Hedgecock, I.M., Pirrone, N. 2004. Chasing quicksilver: modeling the atmospheric lifetime of $\text{Hg}^0_{(g)}$ in the marine boundary layer at various latitudes. *Environ. Sci. Technol.* 38: 69-76.

Jernelov, A. 2000. Some comments on biological methylation, global emissions and trade and on residence time in atmosphere of mercury. *Journal of Environmental Sciences* 12(Supplement): 102-107.

Watras, C. J.; Bloom, N. S.; Hudson, R. J. M.; Gherini, S.; Munson, R.; Claas, S. A.; Morrison, K. A.; Hurley, J.; Wiener, J. G.; Fitzgerald, W. F.; Mason, R.; Vandal, G.; Powell, D.; Rada, R.; Rislov, L.; Winfrey, M.; Elder, J.; Krabbenhoft, D.; Andren, A. W.; Babiarz, C.; Porcella, D. B.; Huckabee, J. W. 1994. Sources and fates of mercury and methylmercury in Wisconsin lakes. *In* Mercury Pollution: Integration and Synthesis; Watras, C. J., Huckabee, J. W., Eds.; Lewis Publishers. pp 153-177.

LOCAL DEPOSITION ASSESSMENT FROM THE NATIONAL MERCURY DEPOSITION NETWORK

TJ Butler, MD Cohen, FM Vermeylen, GE Likens, D Schmeltz, RS Artz, 2008; "Regional precipitation mercury trends in the eastern USA, 1998–2005: Declines in the Northeast and Midwest, no trend in the Southeast," *Atmosph. Env.* 42, 1582–92.

Written Testimony provided to the Committee on Environment and Public Works, United States Senate, Washington, D.C., Leonard Levin, Ph.D., Technical Executive, Electric Power Research Institute, Palo Alto, California, May 13, 2008.

RECENT RESEARCH - AMBIENT MEASUREMENTS OF MERCURY IN WISCONSIN

A.P. Rutter, J.J. Schauer, G.C. Lough, D.C. Snyder, C.J. Kolb, S. Von Kloster, T. Rudolf, H. Manolopoulos and M.L. Olson, *J. Environ. Monit.*, 2008, 10, 102-108.

Supplementary Material (ESI) for *Journal of Environmental Monitoring*. The Royal Society of Chemistry 2007.

H. Manolopoulos, J.J. Schauer, M.D. Purcell, T.M. Rudolph, M.L. Olson, B. Rodger and D. Krabbenhoft, *Journal of Environmental Engineering and Science*. 2007, Vol. 6, 5, 491-501.