11/10/2009

Great Lakes Mercury Emission Reduction Strategy

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1. EXECUTIVE SUMMARY

1.1 Origins and Scope of this Report

This Mercury Emission Reduction Strategy was developed at the direction of the Great Lakes Regional Collaboration (GLRC). The GLRC was convened by federal agencies, Great Lakes governors, Great Lakes mayors, Great Lakes tribes, and members of the Great Lakes States Congressional Delegation. Members of the Great Lakes Regional Collaboration include the Great Lakes Interagency Task Force, the Council of Great Lakes Governors, the Great Lakes and St. Lawrence Cities Initiative, the Great Lakes Native American Tribes, and the Great Lakes Congressional Task Force.

This Strategy is a project of the GLRC and seeks to complement and enhance the recommendations in the Quicksilver Caucus's Action Plan and Implementation Strategy for reducing mercury in the environment (see Appendix C). Implementation of this strategy is one important element in achieving virtual elimination of mercury inputs into the Great Lakes as envisioned in the Great Lakes Binational Toxics Strategy[1]. The GLRC endorses the recommendations of the Strategy as valid options for consideration by Great Lakes states and, for one of the recommendations, the federal government. The GLRC does not expect each state, or the federal government to commit to implementation of all of the recommendations, but rather to consider implementation of those recommendations that are appropriate and feasible in its individual circumstances.

In 2006, the GLRC began a Toxic Pollutants Initiative to implement recommendations in the GLRC Strategy to Restore and Protect the Great Lakes, including the development of a strategy for reducing mercury in products. This Great Lakes Mercury Emissions Reduction Strategy is part of that Initiative. The team responsible for preparing this Strategy is composed of representatives from the environmental agencies of each of the Great Lakes states, the Great Lakes Regional Pollution Prevention Roundtable, and U.S. EPA's Region 5 and Great Lakes National Program Office.

The goal of this Strategy is to reduce mercury emissions within the Great Lakes states and to develop mercury reduction approaches that might serve as an example in other jurisdictions. This effort is meant to produce institutionalized activities to sustain mercury emissions reduction from new and existing sources whose mercury emissions have not been regulated, and from sources where regulations have been implemented but additional cost-effective reductions can be achieved.

1.2 Importance of Mercury Emissions Reductions in the Great Lakes States

Mercury is a naturally occurring metallic element and a potent neurotoxin. Even small quantities of mercury in fish consumed by a pregnant woman can impair the neurological development of her fetus. All of the Great Lakes states have statewide fish consumption advisories for mercury. Moreover, mercury is a problem beyond the Great Lakes; many of the highest mercury exposures result from consumption of seafood.

While there are still significant uncertainties about emissions inventories and the fate and transport of mercury in the environment, the following conclusions can be made with confidence:

- Air deposition is the primary source of mercury to the Great Lakes.
- Mercury deposition to the Great Lakes originates from both natural and anthropogenic sources, and from sources within the Great Lakes states as well as from more distant sources within North America and sources overseas.
- The share of mercury deposition caused by nearby sources varies greatly depending on location. In some cases, high mercury deposition levels occur near to significant sources, where nearby sources (within 100 km, or within the same state) are thought to account for well over half of mercury

[1] http://www.epa.gov/greatlakes/p2/bnssign.PDF

deposition. In areas of the Great Lakes basin that are more distant from concentrations of large mercury emissions sources, the contribution from nearby sources is relatively small.

- The closer a mercury emissions source of a given size and emissions profile is to the Great Lakes, the more deposition it contributes.
- Most of the individual emissions sources that contribute most mercury deposition to the Great Lakes are within the Great Lakes states.
- Coal-fired power plants are by far the largest-emitting sector within the Great Lakes states. While there is some uncertainty in emissions estimates, there is general agreement that after coal-fired power plants, the largest sources of mercury emissions within the Great Lakes states include metals production (primarily from the use of mercury-contaminated metal scrap, but also from virgin raw materials), waste incineration, cement production, fuel combustion at non-utility stationary sources, and mercury cell chlor-alkali plants.
- Modeling indicates that coal-fired power plants within the Great Lakes states account for a significant share of mercury inputs into the Great Lakes.
- The share of mercury deposition to the Great Lakes contributed by global sources is growing, as emissions in Asia and Africa grow while emissions in North America decline.

1.3 Mercury Source Sectors to Address

The Great Lakes Regional Collaboration has called for a Great Lakes Mercury Emissions Reduction Strategy that reduces emissions from "new and existing sources whose mercury emissions have not been regulated," and from sources that have been regulated but nonetheless present opportunities for additional reduction. This Strategy uses the following criteria to identify source sectors that should be evaluated to determine whether there are good opportunities for reduction:

- Source sectors with the highest total emissions.
- Source sectors that might be expected to have high deposition within Great Lakes Basin (due to speciation profile) or high local emissions impact (because of big individual sources).
- Source sectors with potential for future emissions growth.
- Source sectors whose emissions are not already being addressed by federal or basin-wide state regulations or voluntary efforts.
- Source sectors for which states have the ability to go beyond existing or forthcoming regulations/programs.
- Source sectors for which there may be cost-effective opportunities for additional reduction.

Based on the above criteria, we have decided to evaluate the following broad sector categories:

- Utility boilers
- Metals production
- Waste incineration
- Cement production
- Non-Utility fuel combustion
- Mercury cell chlor-alkali plants
- Mercury emission related to product use and disposal

1.4 Recommended Actions

We recommend the following actions:

1.4.1 Fossil Fuel Electric Power Generation

- Recommendation 1: States that are developing or implementing regulations limiting mercury emissions from coal-fired power plants should continue to do so within their proposed schedule.
  Recommendation 2: States should support federal efforts to regulate mercury emissions by providing data and analysis of mercury emissions reductions that have been achieved under state programs and that are projected to be achieved in the future.
- Recommendation 3: States should support regulations that achieve mercury emissions incidentally to other environmental objectives, such as the Clean Air Interstate Rule.
- Recommendation 4: If federal regulations limiting mercury emissions from coal-fired power plants have not been proposed by the end of 2013, states that have not already done so should consider implementation of their own regulations to achieve mercury emissions reductions.
- Recommendation 5: When considering implementation of policies that promote energy efficiency and renewable energy, states should take into account the potential benefits that such policies will have for mercury emissions reduction, along with the other benefits and costs of such policies.

1.4.2 Industrial, Commercial & Institutional Boilers

- Recommendation 6: The U.S. EPA has entered into an order on consent to provide a proposed MACT standard for Industrial/Commercial/Institutional Boilers by April 2010, and in August 2008 issued an Information Collection Request (ICR). The Great Lakes States should supplement the information collected through the ICR by assembling stack testing information to assist in establishing a representative MACT standard for this source category and potential sub-categories Stack testing information should focus on varying fuel types, fuel load, boiler size and control equipment.
- Recommendation 7: When considering implementation of policies that promote energy efficiency and fuel switching, states should take into account the potential benefits that such policies will have for mercury emissions reduction, along with the other benefits and costs of such policies.

1.4.3 Mercury Cell Chlor-Alkali Industry

- Recommendation 8: States should encourage responsible management of surplus commodity grade mercury when a chlor-alkali plant converts to a mercury-free process or closes. Responsible management would include meeting all regulatory requirements related to mercury removal and contracting with experienced and reputable firms.
- Recommendation 9: States should consider offering incentives to expedite the transition to mercury-free chlor-alkali production. Possible incentives could include expediting regulatory approvals, altering compliance deadlines, and state support for stable, long-term electrical rates to add predictability to input costs.

1.4.4 Metals Production

- Recommendation 10: States should implement the recommendations of the *Mercury in Products Phase-Down Strategy* related to phasing out use of mercury devices and to promoting the removal of mercury switches from end-of-life vehicles and appliances.
- Recommendation 11: States should include permit conditions requiring proper management of scrap that is likely to contain mercury switches at metal shredders, contingent on obtaining such authority in states where it is lacking (see recommendation 26).
- Recommendation 12: The Great Lakes states should work with U.S. EPA to identify non-ferrous metals production facilities and determine whether they are subject to emissions control standards for hazardous air pollutants.

- Recommendation 13: States that have taconite production plants should promote participation by these plants in the voluntary mercury reduction activities outlined in the Strategy Framework for Implementation of Minnesota's Statewide Mercury TMDL Implementation Plan, which strive to reduce emissions by 75% by 2025.
- Recommendation 14: States with ferroalloys production facilities should explore mechanisms for incorporating mercury emissions controls into source permits contingent on obtaining such authority in states where it is lacking (see recommendation 26).
- Recommendation 15: States should require use of effective mercury emissions controls at new coke oven facilities, contingent on obtaining such authority in states where it is lacking (see recommendation 26).

1.4.5 Products and Processes that Deliberately Use Mercury

- Recommendation 16: The Great Lakes states should continue to implement the recommendations contained within the Great Lakes Regional Collaboration's *Mercury in Products Phase-Down Strategy* that address mercury bans in products, mandatory recycling and participation in national or regional clearinghouse efforts on mercury product stewardship.[2]
- Recommendation 17: The Great Lakes states should work with the crematory industry to better understand the emission levels from crematories and explore control options to decrease mercury emissions.

  Recommendation 18: The Great Lakes states should recommend the recycling of all mercury-containing lamps, following U.S. EPA's lead. Recycling practices, including accumulation, transportation and processing should conform to industry best practices (as reported by the Association of Lamp and Mercury Recyclers). If the operation of drumcrushers is permitted within the Great Lakes states, specific conditions should be met. These include, but are not limited to, operation away from sensitive populations such as hospitals, nursing homes and schools; operation with proper controls such as carbon filters. Operators should follow the BMPs established by the Association of Lighting and Mercury Recyclers.
- Recommendation 19: The Great Lakes states should require best available control technology for mercury emissions in air permits for stationary or mobile sources that recycle mercury-containing lamps. Where permitting authority is not available, states should work through P2 and/or compliance assistance programs to achieve reductions.
- Recommendation 20: The Great Lakes states should encourage manufacturing facilities that manufacture products that contain mercury, including switches, relays, dental amalgams, to find environmentally-preferred alternatives. If no alternatives exist, states should encourage manufacturers to control mercury using best management practices and eventually consider regulating with best available control technology via air permits. States may also consider encouraging or requiring manufacturers to implement take-back programs for mercury-containing devices similar to the Thermostat Recycling Corporation's thermostat reverse distribution program.[3]
- Recommendation 21: The Great Lakes states should require autoclaves that process /sterilize waste from health care and dental facilities to implement a waste management plan that assures removal of mercury from the waste stream. States should also consider requiring mercury controls through an air permit or other means, as deemed necessary.

1.4.6 Portland Cement

Recommendation 22: States with cement production facilities should explore mechanisms for incorporating mercury emissions controls into source permits contingent on obtaining such authority in states where it is lacking (see recommendation 26).

[2] http://www.glrc.us/documents/DraftMercuryPhaseDownStrategy.pdf
[3] http://www.nema.org/gov/ehs/trc/.

1.4.7 Waste Incinerators

- Recommendation 23: States should consider adopting more stringent mercury emissions limits for incineration sources, similar to those implemented by the Northeast states, including New York, as recommended under the Mercury Action Plan of the New England Governors/Eastern Canadian Premiers.
- Recommendation 24: States should implement the recommendations of the GLRC *Mercury in Products Phase-Down Strategy* in order to help reduce the amount of mercury that reaches incinerators in municipal, medical, and industrial waste, and to reduce the mercury content of sewage sludge.
- Recommendation 25: Great Lakes states that do not have prohibitions on uncontrolled on-site waste incineration should consider banning this activity. State with bans should increase compliance efforts. Regardless of the regulatory status of on-site incineration all states should implement initiatives to divert mercury-added products to appropriate management.

1.4.8 Cross Cutting Strategies to Address All Mercury Emission Sources

- Recommendation 26: All states should require Best Available Control Technology (BACT) for mercury emissions from new and modified air sources. States that do not currently have the authority to require BACT for new and modified air sources should consider legal changes that would provide such authority, considering a threshold of 10 pounds or less of mercury per year.
- Recommendation 27: The Great Lakes states recommend that EPA use the existing authority in Section 112(a) of the Clean Air Act to establish a major source category threshold for mercury that is a lesser quantity, appropriately reflecting the quantities in which mercury is actually released, and its potency, persistence and potential for bioaccumulation.
- Recommendation 28: States should consider mandatory reporting for new and existing sources that emit mercury, considering a threshold of 5 pounds per year or less.
- Recommendation 29: States should consider adopting policies that would allow multipathway risk assessments to be conducted as part of the construction permit process.
- Recommendation 30: States should contribute BACT data on mercury emissions controls to the national RACT/BACT/LAER Clearinghouse (RBLC) in order to make it into an effective resource for information on mercury controls, in addition to the existing information that it provides on criteria air pollutants.
- Recommendation 31: States should continue to promote awareness of mercury issues.
- Recommendation 32: States should consider voluntary approaches along with regulatory approaches when addressing mercury emissions sources.

1.4.9 Tracking Progress On Implementation

- Recommendation 33: Each of the Great Lakes state environmental agencies should publicly identify its implementation priorities and the organizations responsible for achieving them.
- Recommendation 34: Each of the Great Lakes States environmental agencies and the U.S. Environmental Protection Agency appoint a representative to a workgroup tasked with tracking progress on implementation of the recommendations in this report and for sharing information about implementation priorities and approaches. This workgroup should invite participation from Environment Canada, the Ontario Ministry of the Environment, and Québec's Ministry of Sustainable Development, Environment, and Parks, and seek stakeholder input.

2. GOAL AND BACKGROUND

The goal of this effort, as defined by the Great Lakes Regional Collaboration (GLRC), is to produce institutionalized activities to sustain mercury emissions reduction from new and existing sources whose

mercury emissions have not been regulated, and from sources where regulations have been implemented but additional cost-effective reductions can be achieved.

2.1 Origins and Scope of this Report

This Mercury Emission Reduction Strategy was developed in response to the GLRC Toxic Pollutants Initiative.[4] This Initiative calls for the development of a basin-wide mercury emission strategy designed to phase out the use of mercury and provide for mercury waste management. The GLRC was convened by federal agencies, Great Lakes governors, Great Lakes mayors, Great Lakes tribes, and members of the Great Lakes States Congressional Delegation. Members of the Great Lakes Regional Collaboration include the Great Lakes Interagency Task Force, the Council of Great Lakes Governors, the Great Lakes and St. Lawrence Cities Initiative, the Great Lakes Native American Tribes, and the Great Lakes Congressional Task Force.

This Emission Reduction Strategy is a project of the GLRC and seeks to complement and enhance the recommendations in the Quicksilver Caucus's Action Plan and Implementation Strategy for reducing mercury in the environment (see Appendix C). Implementation of this strategy is one important element in achieving virtual elimination of mercury inputs into the Great Lakes as envisioned in the Great Lakes Binational Toxics Strategy[5]. The GLRC endorses the recommendations of the Strategy as valid options for consideration by Great Lakes states and, for one of the recommendations, the federal government. The GLRC does not expect each state, or the federal government to commit to implementation of all of the recommendations, but rather to consider implementation of those recommendations that are appropriate and feasible in its individual circumstances.

The team responsible for preparing this Strategy is composed of representatives from the environmental agencies of each of the Great Lakes states, the Great Lakes Regional Pollution Prevention Roundtable, and U.S. EPA's Region 5 and Great Lakes National Program Office.

This report is not meant to be a comprehensive summary of actions needed to reduce mercury releases to the Great Lakes. It addresses mercury air emissions within the Great Lakes states. A second report, the *Mercury in Products Phase-Down Strategy*, addresses use and disposal of mercury-containing products within the Great Lakes states. While addressing mercury emissions, mercury product use and mercury disposal within the Great Lakes states is important, these actions alone will not be sufficient to protect the Great Lakes ecosystem from mercury and allow for the removal of fish consumption advisories throughout the Great Lakes and in nearby inland lakes. Most of the mercury inputs into the Great Lakes come from overseas emissions of mercury, combined with naturally-occurring mercury. Therefore, international action to reduce mercury emissions is needed.

2.2 The Need for Mercury Emissions Reduction

Mercury is a naturally occurring metallic element and a potent neurotoxin.[6] Even small quantities of mercury in fish consumed by a pregnant woman can impair the neurological development of her fetus.[7] Young children are also vulnerable to mercury exposure, and it can create health risks for adults. Nationwide, mercury is the most common cause for state health departments to issue advisories warning against unrestricted consumption of certain locally-caught fish. All of the Great Lakes states have statewide fish consumption

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[4] Great Lakes Regional Collaboration Mercury Emission Reduction Initiative October 2007. http://www.glrc.us/initiatives/toxics/HgReduction10-2007.html

[5] http://www.epa.gov/greatlakes/p2/bnssign.PDF

[6] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards and Office of Research and Development. Mercury Study Report to Congress, Volume V: Health Effects of Mercury and Mercury Compounds; EPA-452/R-97-007 (December 1997).

[7] Water Quality Criterion for the Protection of Human Health: Methylmercury; EPA-823-R-01-001, EPA-823-R-01-001, U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, January 2001.

advisories for mercury. Mercury contamination problems are, in many cases, more serious in the inland lakes and rivers of the Great Lakes states than in the Great Lakes themselves.[8] Moreover, mercury is a problem beyond the Great Lakes states; the highest mercury exposures result from consumption of seafood. In addition to exposure through eating contaminated fish, people can be poisoned by breathing mercury vapors. Mercury vapor can sometimes reach dangerous levels when mercury is spilled indoors; exposure to mercury vapor outdoors is not considered a significant risk in most circumstances.[9]

Scientists have determined that in many locations, including the Great Lakes, atmospheric deposition is the primary pathway by which mercury enters surface waters.[10] Mercury is released into the air through both human activities and natural processes, and is eventually deposited into surface water and onto the land. Mercury emissions can travel long distances; while some emissions will deposit locally, some mercury emissions can remain in the atmosphere for six months or more, traveling around the globe. Mercury does not degrade, and it is not destroyed by combustion. In addition, it persists in the environment and bioaccumulates in the aquatic food chain, particularly in the organic form of methylmercury.

A number of factors affect the levels of mercury in fish, other than the mercury concentrations in the water. Water chemistry, sulfate deposition, and bacterial activity powerfully influence the amount of mercury that methylates (and demethylates) in a body of water; the trophic structure of the food web, ecological factors, and fishing practices influence the degree to which methylmercury will bioaccumulate. As a result, it is frequently difficult to attribute temporal trends or spatial patterns in mercury fish concentrations to levels of mercury emissions and deposition. Nonetheless, scientists have concluded that, holding other factors constant, increased mercury deposition resulting from anthropogenic mercury emissions raises mercury concentrations in fish. The world expert panel titled "Recovery of Mercury-contaminated Fisheries" assembled for the 2006 Mercury as a Global Pollutant Conference and stated that, "The main conclusion drawn is that changes in mercury loading (increase or decrease) will yield a response in fish methylmercury, but that the timing and magnitude of the response will vary depending on ecosystem-specific variables and the form of the mercury load".[11] Other published studies have confirmed that increased atmospheric deposition of mercury will lead to an increase in methylmercury concentrations in fish.[12]

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[8] A likely reason for the higher mercury levels in some inland lakes is a higher tendency in some of these lakes for mercury to be in the methylated form. For a discussion of factors related to mercury methylation, see Wiener JG, Krabbenhoft DP, Heinz GH, Scheuhammer AM. 2003. Ecotoxicology of mercury. In: Hoffman DJ, Rattner BA, Burton GA Jr, Cairns J Jr, editors, Handbook of Ecotoxicology, 2nd ed. Boca Raton (FL): CRC Press, P. 409–463.

[9] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards and Office of Research and Development. Mercury Study Report to Congress, Volume VII: Characterization of Human Health and Wildlife Risks from Mercury Exposure in the United States; EPA-452/R-97-009 (December 1997), p 5-2, and National Institutes of Health, Office of Research Facilities, Development and Operations, “Mercury Health Hazards” (website), http://orf.od.nih.gov/Environmental+Protection/Mercury+Free/MercuryHealthHazards.htm.

[10] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards and Office of Research and Development. Mercury Study Report to Congress, Volume III: Fate and Transport of Mercury in the Environment; EPA-452/R-97-005 (December 1997), p. 3-1.

[11] Munthe, J., Bodaly, R.A., Branfireun, B.A., Driscoll, C.T., Gilmour, C.C., Harris, R., Horvat, M., Lucotte, M., Malm, O. 2007. Recovery of mercury-contaminated fisheries. *Ambio*. 36(1):33-44.

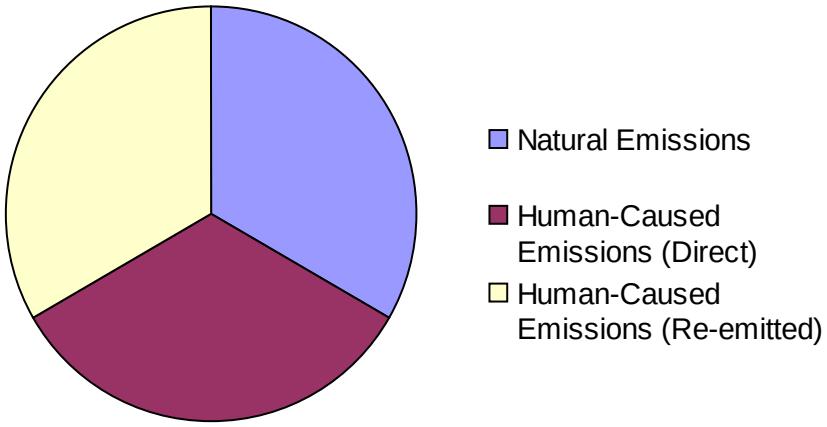
[12] Harris, R.C., Rudd, J.W.M., Amyot, M., Babiarz, C.L., Beaty, K.G., Blanchfield, P.J., Bodaly, R.A., Branfireun, B.A., Gilmour, C., Graydon, J.A., Heyes, A., Hintelmann, H., Hurley, J.P., Kelly, C.A., Krabbenhoft, D.P., Lindberg, S.E., Mason, R.P., Paterson, M.J., Podemski, C.L., Robinson, A., Sandilands, K.A., Southworth, G.R., St. Louis, V.L., Tate, M.T. 2007. Whole-ecosystem study shows rapid fish-mercury response to changes in mercury deposition. PNAS (Proceedings of the National Academy of Sciences) 104(42):16586-16591. See also Watras, C.J., Morrison, K.A., 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.* 59:1669-1667, and Watras, C.J. Morrison, K.A. Regnell, O, Kratz, T.K. 2006. The methylmercury cycle in Little Rock Lake during experimental acidification and recovery. *Limnol. Oceanogr.* 51(1):257-270.

3. SOURCES OF MERCURY EMISSIONS AND DEPOSITION TO THE GREAT LAKES BASIN

3.1 Sources of Mercury in the Global Environment[13]

Mercury cycles in the environment as a result of natural and human (anthropogenic) activities. Natural sources of mercury, such as volcanic eruptions and emissions from the ocean, have been estimated to contribute about ***one third*** of current worldwide mercury air emissions, whereas anthropogenic emissions account for the remaining ***two-thirds.***[14] Today, much of the mercury circulating through the environment is mercury that was released years ago, when mercury was frequently used in many industrial, commercial, and residential products and processes. Anthropogenic emissions are thought to be split roughly equally between these re-emitted emissions from previous human activity, and direct emissions from current human activity, as illustrated in Chart A. There is considerable uncertainty about how much of anthropogenic emissions are direct versus indirect.

Chart A: Contribution of Natural and Anthropogenic Worldwide Mercury Air Emissions.



Source: U.S. EPA, 2005d [15]

Seigneur et al. (2004)[16] compared three global emission scenarios for atmospheric mercury that varied in their distribution of background emissions of direct natural emissions and re-emissions of natural and anthropogenic mercury. For the base scenario, Seigneur assumed that 50 percent of deposited mercury is re-emitted to the atmosphere. A lower bound scenario assumed 33 percent is re-emitted, while the upper bound scenario assumed that 56 percent is re-emitted.

The global mercury budget comparison is illustrated in Table A. Natural mercury emission estimates range from 1100 Mg/yr to 3201 Mg/yr. Natural emissions from land (including re-emissions of natural mercury) range from 500 Mg/year to 1805 Mg/year (lower bound scenario), while natural emissions from oceans (including re-emissions of natural mercury) range from 600 Mg/year to 1396 Mg/year (lower bound scenario).

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[13] U.S. Environmental Protection Agency, Great Lakes National Program Office and Environment Canada. Great Lakes Binational Toxics Strategy Management Assessment for Mercury. February 2006 http://www.epa.gov/region5/mercury/mercury_reassessment_final_feb%2006.pdf.

[14] U.S. EPA 2005d. Mercury Emissions: The Global Context. Last updated on August 11th, 2005. Accessed March 29, 2009, at: http://www.epa.gov/mercury/control_emissions/global.htm.

[15] Ibid

[16] Seigneur C., Vijayaraghavan K., Lohman K., Karamchandani P., and C. Scott. 2004. Global Source Attribution for Mercury Deposition in the United States. *Environ. Sci. Technol.* 38(2):555 – 569.

Direct anthropogenic emissions range from 2143 to 2400 Mg/year. Re-emissions of anthropogenic mercury range from 1067 Mg/year (lower bound scenario) to 2670 Mg/year (upper bound scenario).
The ratio of current emissions to pre-industrial emissions, as well as the percentage of deposited mercury that is re-emitted from the Seigneur et al. base scenario, is consistent with Bergan et al. (1999)[17] and Mason and Sheu (2002)[18] values.

Table A: Comparison of Recent Global Budgets for Atmospheric Mercury.

Emissions	Bergan et al., 1999	Mason and Sheu, 2002	Lamborg et al., 2002	Seigneur, 2004 base	Seigneur, 2004 lower bound	Seigneur, 2004 upper bound
Direct anthropogenic (Mg/year)	2160	2400	4800	2143[a]	2143 [a]	2143 [a]
Re-emitted anthropogenic (Mg/year)	2000	2090		2134	1067	2670
Natural from land[a] (Mg/year)	500	810	1000	1180	1805	878
Natural from oceans[a,] (Mg/year)	1400	1300	600	954	1396	720
Total (Mg/year)	6060	6600	6400	6411	6411	6411
Re-emission/deposition (%)	50	47	NA[c]	50	33	56
Current/pre-industrial emissions	3	3.1	4	3	2	4

[a] Direct anthropogenic emissions of 2143 Mg/year consist of 246, 209, 176, 1138, 326, and 48 Mg/year for Africa, North America, Central and South America, Asia, Europe, and Oceania, respectively.
[b] Including re-emission of natural mercury.
[c] Not available.
Source: Seigneur et al., 2004[19]

Gustin and Lindberg (2005)[20] estimate mercury inputs in line with those in Table A (e.g., global emissions of 6000 to 6600 Mg/y and anthropogenic estimates of 2000 to 2400 Mg/y). However, the authors suggest that re-emission of previously deposited mercury may be greater than previously estimated. The more rapid re-emission of deposited mercury means that there will be a delay of many years before emissions controls lead to significant reductions in the global pool of mercury.[21]

[17] Bergan, T.; Gallardo, L.; Rohde, H. *Atmos. Environ.* 1999, *33*, 1575-1585.
[18] Mason, R. P.; Sheu, G.-R. *Global Biogeochem. Cycles* 2002, *16*.
[19] Seigneur C., Vijayaraghavan K., Lohman K., Karamchandani P., and C. Scott. 2004. Global Source Attribution for Mercury Deposition in the United States. *Environ. Sci. Technol.* 38(2):555 – 569.
[20] Gustin, M.S. and S.E. Lindberg. 2005. Terrestrial mercury fluxes: Is the net exchange up, down, or neither? In *Dynamics of Mercury Pollution on Regional and Global Scales: Atmospheric Processes,Human Exposure Around the World*; Pironne, N., Mahaffey, K. Eds.; Springer: Norwell, MA, 2005; Chapter 11, pp 241-260.
[21] Gustin, M.S. and S.E. Lindberg. 2005. Terrestrial mercury fluxes: Is the net exchange up, down, or neither? In *Dynamics of Mercury Pollution on Regional and Global Scales: Atmospheric Processes,Human Exposure Around the World*; Pironne, N., Mahaffey, K. Eds.; Springer: Norwell, MA, 2005; Chapter 11, pp 241-260.

3.2 Sources of Mercury in Deposition in North America

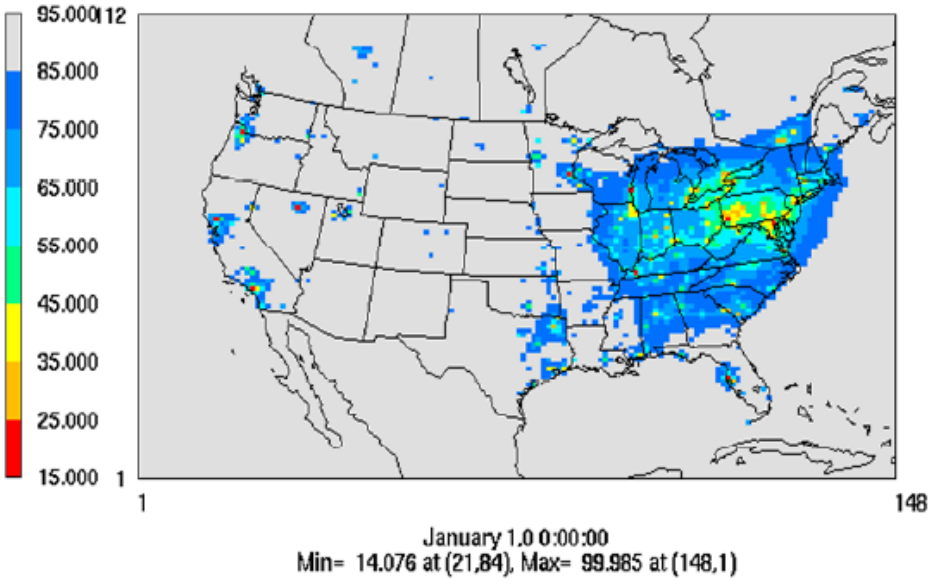
The flux of mercury from the atmosphere to land or water at any one location is comprised of contributions from natural and human-caused sources, which can be local, regional or global.[22] A variety of techniques can be used to estimate the relative contributions of different types of emission sources to mercury deposition at a given location. Deterministic models use an emissions inventory and model the movement of mercury in the atmosphere and the chemical reactions that influence the wet and dry deposition of mercury. These models are combined with meteorological inputs to produce estimates of total mercury deposition at a given location, as well as estimates of the mercury deposition caused by an individual source or group of sources.

U.S. EPA utilizes two different deterministic models, the Community Multiscale Air Quality (CMAQ) model, and the Regional Modeling System for Aerosols and Deposition (REMSAD). Using CMAQ, U.S EPA estimates that out of 144 tons of mercury deposited in the U.S., 23 tons (16 percent) resulted from U.S. and Canadian anthropogenic mercury emissions. The remaining 84 percent, according to the model, comes from global anthropogenic sources, natural sources, and re-emission of previously deposited mercury.[23]

However, these U.S. averages conceal tremendous variation from place to place within the U.S. Figure A shows the share of mercury deposition within the U.S. attributed to global (natural and non-U.S. or Canadian anthropogenic) sources. The places with the lowest share of deposition from the global source contribution, and therefore the highest share from the U.S./Canadian source contribution, are also the places with the highest total deposition. In some places, U.S. and Canadian sources account for most of the mercury deposition. Locations that are close to mercury sources, particularly to sources of reactive gaseous mercury (or oxidized mercury), which tends to deposit close to the source, are more likely to have high levels of mercury deposition. Waste incinerators were the largest sources of reactive gaseous mercury emissions in 1990; these emissions have subsequently been well controlled. Compliance with recently promulgated and forthcoming mercury rules is expected to reduce future U.S. deposition caused by U.S. sources, particularly in areas of highest deposition.

[22] U.S. EPA 1997. Mercury Study Report to Congress. Office of Air Quality Planning and Standards and Office of Research and Development. EPA-452-R-97 -003 through -010 (Volumes I - VIII). Access: http://www.epa.gov/mercury/report.htm.
[23] U.S. EPA 2005f. Mercury Deposition in the United States, Access: http://www.epa.gov/mercuryrule/pdfs/slide2rev1.pdf.

Figure A: Percent of Total Mercury Deposition Attributable to Global Sources: 2001.



Source: U.S. EPA, 2005g[24]

It is important to remember, in reviewing these results, that there are many uncertainties in both the inputs and in the models themselves. Moreover, the model results may understate variation from place to place in local source contribution. The CMAQ modeling produces results averaged across 36 kilometer square grid cells, but there may be a large variation in actual deposition within a grid cell.

Previous U.S. EPA estimates had found a much larger contribution from domestic sources. According to the 1997 EPA Mercury Study Report to Congress, 60 percent of mercury deposited in the U.S. originated from anthropogenic mercury emissions within the U.S. The remaining 40 percent came from the global reservoir, which includes anthropogenic, natural and re-emitted sources. The downward revision in the estimate of the impact of U.S. sources on mercury deposition results in part from decreases in U.S. emissions, particularly the dramatic reduction in emissions of oxidized mercury from incinerators. The revised estimate also is based on a revised understanding of global emissions and of mercury behavior in the atmosphere, and from the use of a more sophisticated model.

Seigneur et al. (2004)[25] utilized a deterministic model to estimate that North American anthropogenic sources contribute 30 percent to the total mercury deposition over the continental U.S; other anthropogenic emission sources contribute 37 percent (with Asia contributing the most at 21 percent), while natural emissions account for the remaining 33 percent. This average conceals significant spatial variation; at selected receptors, the estimated contribution of North American anthropogenic emissions ranged from 9 to 81 percent. Seigneur et al.

[24] U.S. EPA 2005g. Technical Support Document: Revision of December 2000 Regulatory Finding on the Emissions of Hazardous Air Pollutants From Electric Utility Steam Generating Units and the Removal of Coal and Oil-Fired Electric Utility Steam Generating Units from the Section 112(c) List: Reconsideration, October 21, 2005, Figure 11.1. Access: http://www.epa.gov/ttn/atw/utility/TSD-112-final.pdf.

[25] Seigneur C., Vijayaraghavan K., Lohman K., Karamchandani P., and C. Scott. 2004. Global Source Attribution for Mercury Deposition in the United States. *Environ. Sci. Technol.* 38(2):555 – 569.

(2003)[26] suggests that current models of the atmospheric fate and transport of mercury may overestimate the local and regional impacts of some anthropogenic emission sources. Therefore, according to Seigneur, the calculated contributions of anthropogenic North American emissions are likely to represent upper bounds of actual contributions.

Swain and Engstrom (1997)[27] used sediment cores to measure mercury concentrations and assess deposition trends in eight lakes in rural Minnesota (four in the eastern portion and four in the western part of the state) and four urban lakes in western Minneapolis, Minnesota. They compared these deposition trends with trends derived from assessment of sediment cores in Alaska lakes. The study concluded that mercury deposition has declined slightly in the upper Midwest since peaking in the 1960s and 1970s, but that mercury deposition caused by globally-transported mercury has continued to increase. The decreased deposition observed in the Midwest was most likely triggered by reduced emissions from regional sources of mercury. The investigators estimated that roughly 40 percent of mercury deposited in the Midwest was from "regional anthropogenic contributions," with 30 percent from "global anthropogenic emissions" and 30 percent from natural sources.

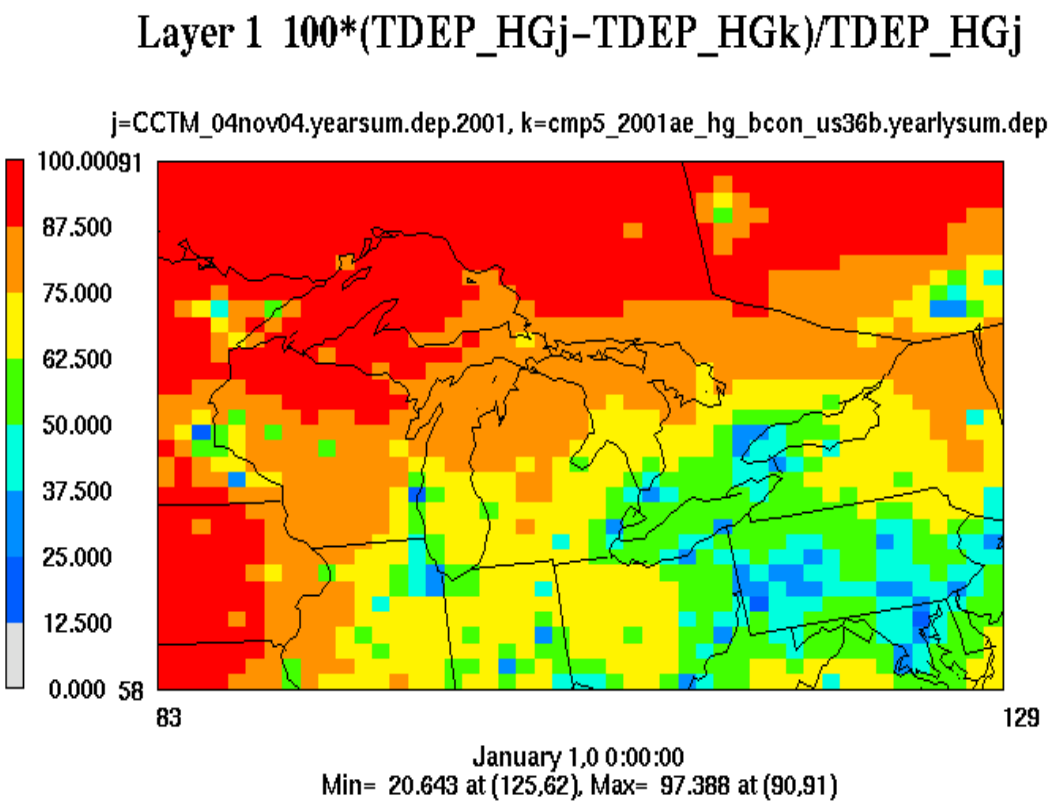
A 2006 study by scientists at the University of Michigan and U.S. EPA estimated the contribution of local and regional sources to mercury deposition in Steubenville, Ohio (in the Ohio River Valley, outside of the Great Lakes basin), using receptor modeling.[28] Receptor modeling, unlike deterministic modeling, begins with sampling of wet mercury deposition at a monitoring site, then combines measurements of trace elements and major anions with a multivariate statistical model and air mass trajectory analysis to assess the source of the mercury to the monitoring site. The Steubenville study utilized daily event-based wet deposition sampling and two different multivariate statistical models. It found that mercury deposition to this location was dominated by nearby sources (within 300 miles), particularly coal combustion sources. Coal combustion sources were estimated to contribute 69-73 percent of deposition, while iron and steel production (or, in one model, nickel, iron and steel production) contributed 6-12 percent. In one model, incineration sources were estimated to contribute 12 percent of mercury deposition, while in the other, incinerator sources did not contribute significantly to mercury deposition. The Steubenville site is within 50 km of five large coal-fired electric utility boilers and within 100 km of 17 such boilers, and is also near to several steel production facilities.

3.3 Mercury Deposition to the Great Lakes Region

U.S. EPA modeling using the CMAQ modeling system shows that the share of mercury deposition to the Great Lakes region resulting from sources outside of North America varies greatly, and is higher in the upper lakes than in the lower lakes. Figure B shows that the non-U.S./Canada share for deposition to most of Lake Superior is estimated to be more than 87.5 percent. By contrast, the non-U.S. share of deposition to Lake Erie is less than 62.5 percent. CMAQ is a three-dimensional air quality model designed to estimate pollutant concentrations and depositions over large spatial scales (e.g., over the Great Lakes Basin). Because it accounts for spatial and temporal variations as well as differences in the reactivity of mercury species, EPA considers CMAQ to be the best available model for evaluating regulations which result in mercury deposition.[29] The modeling shown in Figure B is based on the 1999 U.S. emissions inventory, updated with 2002 data for medical waste incinerators, along with inventory data for Canada.

Figure B: Percent of CMAQ Mercury Deposition from Non-U.S./Canada Sources

[26] Seigneur, C., Karamchandani, P., Vijayaraghavan, K., Shia, R.L., Levin, L. *Sci Total Environ.* 2003, 304, 73-81.
[27] Swain, E.B. and D.R. Engstrom. 1997. Recent declines in atmospheric mercury deposition in the Upper Midwest. *Environ. Sci. Technol*. 31(4): 960-967.
[28] Keeler, Gerald J., Matthew S. Landis, Gary A. Norris, Emily M. Christianson, and J. Timothy Dvonch. "Sources of Mercury Wet Deposition in Eastern Ohio, USA." *Environmental Science and Technology*. 40 (2006): 5874-5881.
[29] U.S. EPA 2005c. Technical Support Document for the Final Clean Air Mercury Rule, Air Quality Modeling. U.S. Environmental Protection Agency. March 2005. Access: http://www.epa.gov/ttn/atw/utility/aqm_oar-2002-0056-6130.pdf.



Source: Office of Air Quality Planning and Standards, Generated by CMAQ Version 4.3 with Mercury, May 2005.

U.S. EPA used another deterministic model, REMSAD, to evaluate mercury deposition within each of the lower 48 states, based on 2001 emissions. For each state, the location where within-state sources contributed the most mercury deposition was determined. The model then showed the percentage of mercury deposition at that location caused by sources within the state, within neighboring states, within non-neighboring states within the United States, within Canada and Mexico, by "background" sources (natural sources and anthropogenic sources outside of North America) and by re-emissions of previously-deposited mercury. The results of this exercise for each of the Great Lakes States are summarized in Table B. It is important to note that these results represent the location of maximum mercury deposition caused by within-state sources, and that they do not reflect state-wide averages. In some cases, but not all, the location of maximum deposition was within the Great Lakes basin.[30]

[30] ICF International. Model-Based Analysis and Tracking of Airborne Mercury Emissions to Assist in Watershed Planning: Final Report, November 30, 2006, Prepared for U.S. EPA Office of Water, Washington, D.C.

Table B: Percentage of Mercury Deposition within State Resulting from Sources of Various Types, at the Site of Maximum Impact from Within-State Sources						
	Within-state	Neighboring States	Other U.S.	Canada/Mexico	Background	Re-emissions
NY	45.6	4.7	10.3	5.7	32.2	1.5
PA	89.8	1.6	1.2	0.1	9.2	0.4
IL	56.3	5.8	3.7	0.1	32.6	1.4
IN	56.7	7.5	3.4	0.1	35.3	1.9
MI	61.7	3.2	3.4	2.0	28.4	1.3
MN	55.4	0.4	3.3	0.2	39.2	1.5
OH	42.2	10.2	4.5	0.2	45.7	3.1
WI	50.9	2.3	3.5	0.1	41.6	1.6

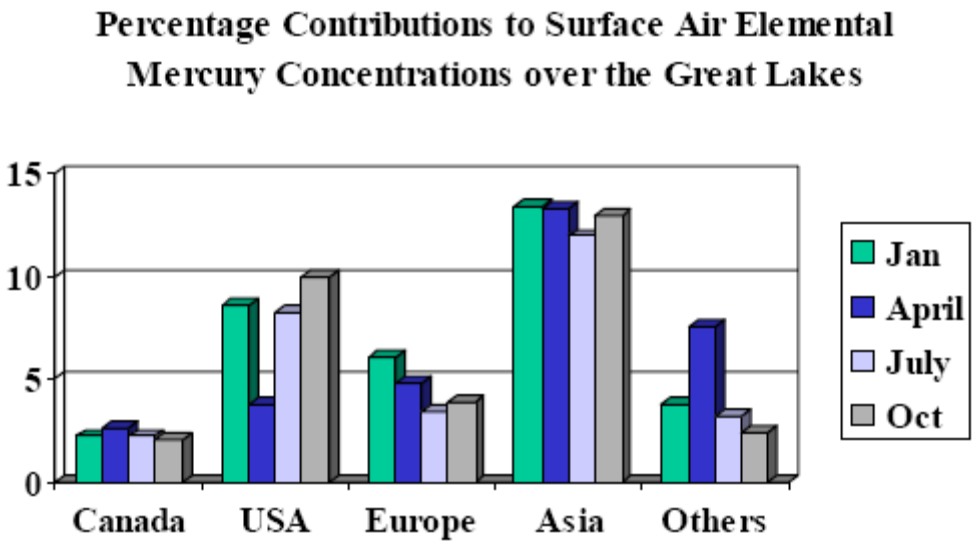
Table B shows that there is considerable variation among states in the share of mercury deposition contributed by within-state sources at the side of maximum impact of these sources, ranging from nearly 90 percent in Pennsylvania to 42 percent in Ohio. In each Great Lake state, the combined impact of sources within the state and neighboring states was more than 50 percent at the site of maximum deposition impact of within-state sources. In every state except Pennsylvania, background sources and sources in Canada and Mexico accounted for at least 30 percent of deposition at these sites of maximum within-state impact.

The Meteorological Service of Canada (MSC) has utilized another model-- the global/regional atmospheric heavy metals model (GRAHM) -- to evaluate the sources of mercury deposition and atmospheric mercury concentrations.[31] Ashu Dastoor of MSC has provided the Great Lakes Binational Toxics Strategy mercury workgroup with this model's estimation of the impacts of global sources on the Great Lakes.[32] Chart B shows the seasonal contributions from the different continents to surface air elemental mercury concentrations over the Great Lakes. Seasonal differences are noticeable. For example, while Asian contributions are the highest overall, during April, the highest mercury contributions from the 'others' category, which includes sources in the southern hemisphere.

[31] Dastoor, A.P. and Larocque, Y., Global circulation of atmospheric mercury: a modelling study, *Atmos Environ* **38** (2004), pp. 147–161.

[32] Dastoor, A. Meteorological Service of Canada. 2004. Presentation at Great Lakes Binational Toxics Strategy Mercury Workgroup Meeting, June 17, 2004.
Dastoor, A. Meteorological Service of Canada. 2005. Personal communication.

Chart B: Percentage Contributions to Surface Air Elemental Mercury Concentrations Over the Great Lakes.



Note: "Others" is defined as other regions of anthropogenic emissions such as all Southern hemispheric emissions.

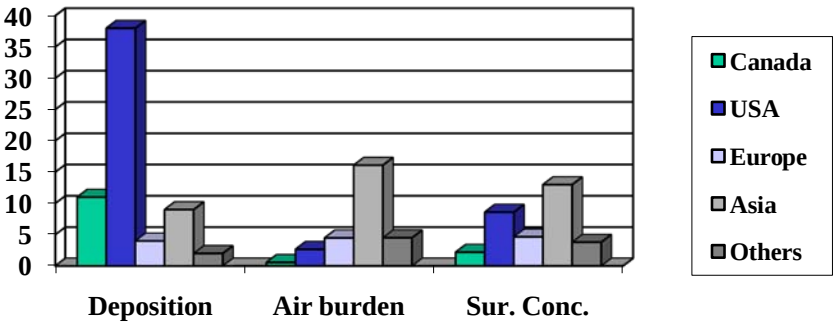
Source: Dastoor, 2004[33]

Chart C shows annual average contributions from global sources to the deposition, air burden (or the total mercury loading to the airshed) and surface air concentrations of mercury over the Great Lakes. This graph illustrates the importance of differences in contributions from global sources in different media. For example, contribution to the air burden is highest from Asia but deposition is highest from North American sources. The figure indicates that the largest percentage of deposition in 1995 was caused by North American emissions. However, experiments recently performed using year 2000 inventory data have determined that the contribution of mercury deposition from North American sources has decreased, while the contributions from Asia and other regions (excluding Europe) have increased.[34]

[33] Dastoor, A. Meteorological Service of Canada. 2004. Presentation at Great Lakes Binational Toxics Strategy Mercury Workgroup Meeting, June 17, 2004.
[34] Dastoor, A. Meteorological Service of Canada. 2005. Personal communication.

Chart C: Annual Average Mercury Contributions to the Great Lakes (1995).

For the deposition category, the balance of the mercury contributions (36 percent) to the Great Lakes is derived from natural and re-emissions from historic deposition from anthropogenic and natural sources. [this is unclear]



Source: Dastoor, 2005[35]

Seigneur et al.[36] estimated that at Devil's Lake, Wisconsin (MDN site WI31), North American anthropogenic emissions contribute 34 percent of mercury deposition with other global anthropogenic emissions contributing 40 percent, and natural emissions contributing 26 percent.

Using a global mercury transport model, Selin and Jacob estimated that as much as 50 percent of mercury deposition in the Midwest was attributable to North American anthropogenic sources, with 30 percent or more typical of the southern Great Lakes states, and a significantly smaller contribution from North American sources in Minnesota, Northern Wisconsin, and northern Michigan.[37] Bookman et al. have estimated that local and regional emissions sources likely contributed 80 percent to deposition in central New York lakes.[38]

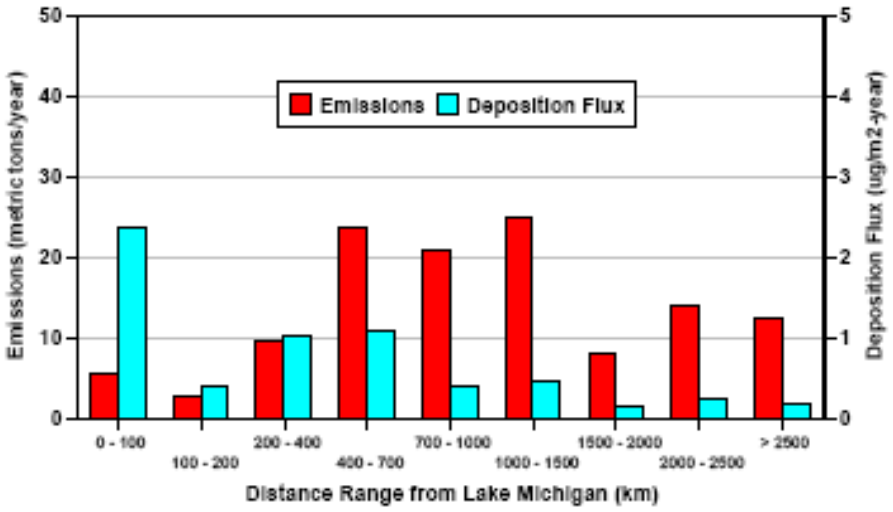
In 2007, the National Oceanic and Atmospheric Administration (NOAA) submitted a Report to Congress on Mercury Contamination in the Great Lakes.[39]. It reported the results of atmospheric modeling of mercury emissions within the United States and Canada, including estimates of the impact of major individual sources and source sectors on mercury deposition to each of the Great Lakes. The NOAA modeling was based on 1999-2001 mercury emissions within the United States, and 1995-2000 mercury emissions within Canada, and did not estimate the impact of natural sources or global anthropogenic mercury sources.

This modeling showed that mercury emissions within the Great Lakes have a significant impact on mercury deposition to the Great Lakes. For instance, Chart D shows estimated mercury deposition impacts to Lake Michigan, along with total mercury emissions, from North American sources at various distances from the

[35] Dastoor, A. Meteorological Service of Canada. 2005. Personal communication.
[36] Seigneur C., Vijayaraghavan K., Lohman K., Karamchandani P., and C. Scott. 2004. Global Source Attribution for Mercury Deposition in the United States. *Environ. Sci. Technol.* 38(2):555 – 569.
[37] N.E. Selin and D.J. Jacob. Seasonal and spatial patterns of mercury wet deposition in the United States: Constraints on the contribution from North American anthropogenic sources. Atmos. Environ., 42:5193-5204, 2008.
[38] R. Bookman, C.T. Driscoll, D.R. Engstrom and S.W. Effler. Local to regional emission sources affecting mercury fluxes to New York lakes. Atmos. Environ. 42:6088-2097, 2008.
[39] Cohen, M.D., Artz, R.S. and Draxler, R.R., Report to Congress: Mercury Contamination in the Great Lakes, Silver Spring, MD: National Oceanic and Atmospheric Administration, April 17, 2007.

Lake. The figure shows that the closer the emissions source, the larger the impact on a pound per-pound basis. Despite the relatively small amount of mercury emissions from sources within 100 km of Lake Michigan, such sources had a large deposition impact. Sources within 100 km contributed more than 2 µg mercury per square meter of Lake Michigan surface area per year, according to the model; for context, total deposition flux to Lake Michigan is approximately 12.6 µg/m^2/year.[40] More distant sources contributed significantly as well, with total modeled deposition from sources between 100 to 700 km from Lake Michigan roughly equal to deposition from sources less than 100 km away. While roughly three-quarters of North American emissions occur more than 700 km away from Lake Michigan, these emissions account for only one-third of the deposition to the Lake caused by North American sources, according to the model. Similar patterns were found for Lake Erie and Lake Ontario, but a much smaller amount of mercury deposition to Lake Superior and Lake Huron is caused by sources within 100 km, because mercury emissions are much lower in the vicinity of these lakes.

Chart D: Emissions and Deposition Arising from Different Distances from Lake Michigan



Source: Cohen, 2007[41], based on 1999-2001 emissions.

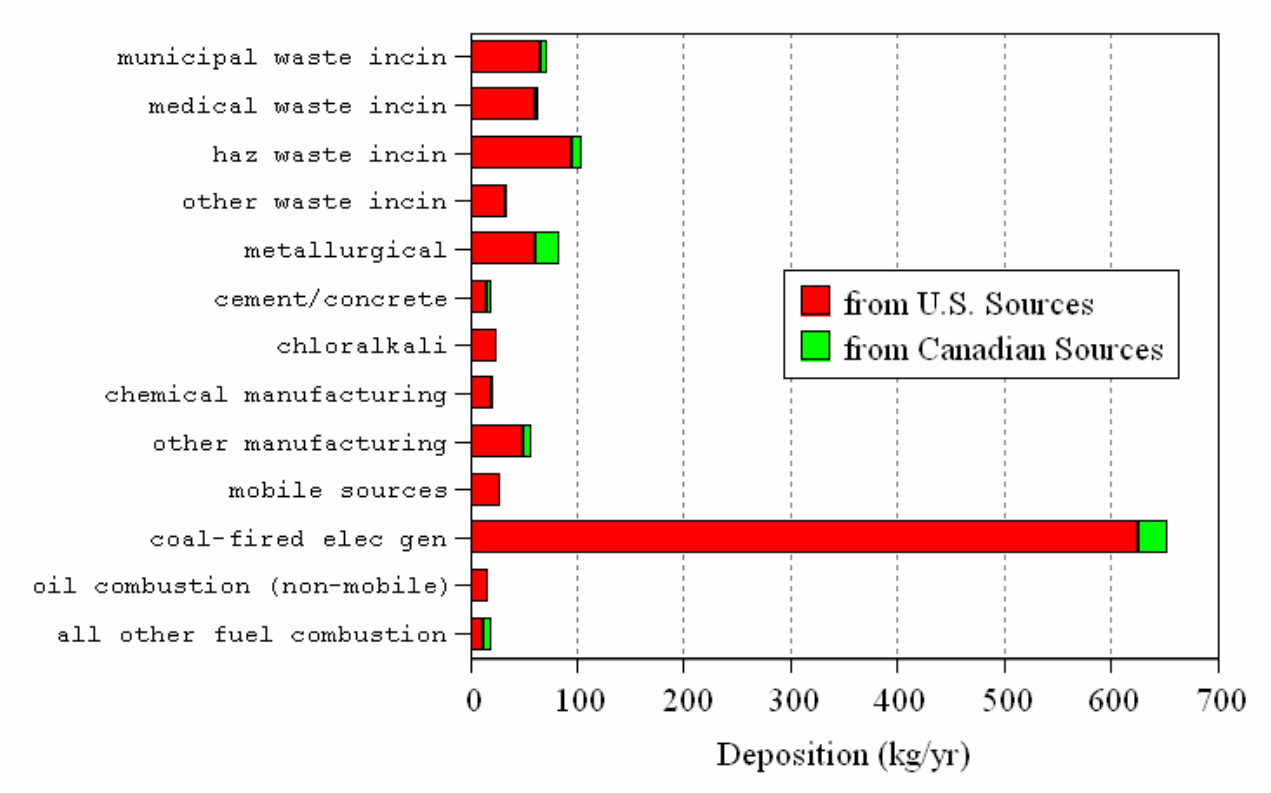
The NOAA Report to Congress also estimated that coal-fired power plants are the most important source sector causing mercury deposition to the Great Lakes. Chart E shows estimated mercury deposition by source sector to the Great Lakes. Coal-fired power plants account for several times more deposition that any other source category, followed by hazardous waste incinerators, other types of waste incinerators (medical, municipal, and industrial) and metallurgical processes. The largest metallurgical contributions to the Great Lakes come from large gold mines in Nevada and Western Canada which, according to the model, have a larger deposition impact than closer but smaller metallurgical sources located within the Great Lakes states, such as taconite mines. Mercury emissions from the Nevada gold mines have been significantly reduced since the 1999 – 2001 inventory that the NOAA modeling is based on. It is important to note that the NOAA modeling is based on inventories that did not adequately quantify mercury emissions from electric arc furnaces and other facilities that melt auto scrap and other equipment that can contain mercury devices. Such facilities are the second

[40] Based on the finding of the Lake Michigan Mass Balance that total atmospheric loadings to the lake are 729 kg/year (see http://www.epa.gov/glnpo/lmmb/results/loadmerc.html), while the surface area of Lake Michigan is 57,800 square kilometers.

[41] Cohen, M.D., Artz, R.S. and Draxler, R.R., Report to Congress: Mercury Contamination in the Great Lakes, Silver Spring, MD: National Oceanic and Atmospheric Administration, April 17, 2007.

largest source of mercury emissions after coal-fired power plants, according to the most recent inventories, but they are not a significant source in the inventories NOAA used.

Chart E: Modeled Deposition to the Great Lakes from Different Source Sectors

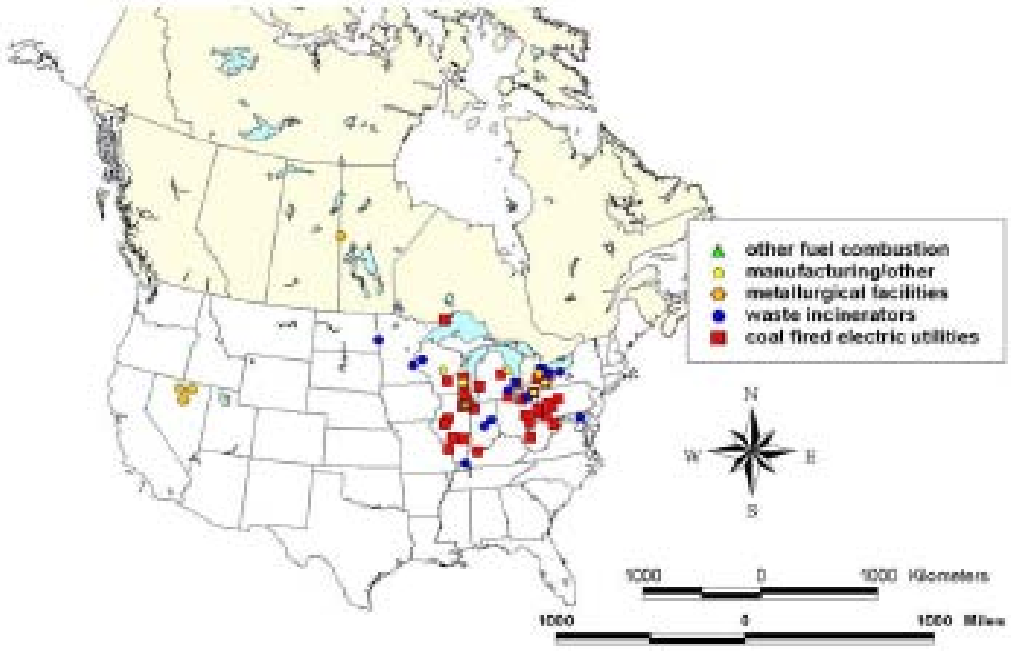


Source: Cohen, 2007[42], based on 1999-2001 emissions.

The NOAA study also shows the 25 individual sources that are believed to contribute the most deposition to each of the Great Lakes. These 25 largest contributors were responsible for between just over 20 percent (Lake Superior) to 40 percent (Lake Erie) of the modeled deposition from North American sources. For each of the Great Lakes, the majority of the top 25 sources are located in the Great Lakes states, and include a mixture of electric generation, incineration, metallurgical and other industrial sources. Figure C is a map showing the locations and source sectors of the sources that were in the top 25 for one or more of the Great Lakes.

[42] Cohen, M.D., Artz, R.S. and Draxler, R.R., Report to Congress: Mercury Contamination in the Great Lakes, Silver Spring, MD: National Oceanic and Atmospheric Administration, April 17, 2007.

Figure C: Largest Modeled Contributors to the Great Lakes



3.4 Mercury Emissions Inventory for the Great Lakes States

The above survey of the scientific literature indicates that emissions sources within the Great Lakes have an appreciable impact on mercury deposition to the Great Lakes. A more detailed evaluation of these sources follows.

EPA compiles a National Emissions Inventory (NEI), based on state emissions inventories combined with national-level estimates. A summary of the 2005 NEI for mercury emissions in the Great Lakes States, aggregating broad source categories, is presented in Table C. The estimates for many of the sectors are based on substantial data and testing, including the largest sector, utility boilers. However, for many other sectors, emissions are highly uncertain, and are based on little data.[43] Utility boilers are by far the largest source of mercury emissions to the atmosphere in the Great Lakes states, accounting for an estimated 57 percent of total 2005 emissions. They are also the largest source of mercury emissions in each of the individual Great Lakes states except Minnesota and New York. Coal combustion at utility boilers resulted in an estimated 19.8 tons of mercury emissions in 2005; only 0.1 tons came from utility boiler oil combustion.

After utility boilers, the source sectors that account for most mercury emissions in the Great Lakes states are metals production (14 percent), non-utility fuel combustion (nine percent), waste incineration (eight percent) cement production (four percent) and chlor-alkali production (three percent). This source sector breakout assigns hazardous waste incineration at Portland Cement plants and lightweight aggregate kilns to the waste incineration category; while we do not have a breakout of these emissions in 2005, in the 2002 NEI, emissions from hazardous waste incineration at cement production facilities accounted for four percent of mercury emissions in the Great Lakes states.

[43] Murray and Holmes (2004) discuss some of the uncertainties in mercury emissions inventories for the Great Lakes region.

Table C: 2005 Mercury Emissions by Sector, Great Lakes States (tons)

	Great Lakes States Total	IL	IN	MI	MN	NY	OH	PA	WI
Utility Boilers	19.9	4.2	2.9	1.8	0.7	0.5	3.7	5.0	1.1
Metals Production	4.9	1.2	0.5	0.3	0.6	0.1	1.0	1.1	0.0
Non-Utility Fuel Combustion	3.0	0.3	0.4	0.4	0.1	0.5	0.2	0.9	0.4
Waste Incineration	2.9	0.3	1.4	0.1	0.1	0.5	0.2	0.4	0.1
Portland Cement	1.4	0.1	0.2	0.6	0.0	0.3	0.0	0.3	0.0
Chlor-Alkali and Other Chemical Manufacturing	1.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.6
Other	1.7	0.5	0.1	0.2	0.1	0.3	0.2	0.2	0.1
Total	34.9	6.6	5.5	3.4	1.6	2.1	5.7	7.8	2.3

These categories were derived by adding together emissions for the following NEI source categories.
--Utility boilers: Utility Boilers (coal) and Utility Boilers (oil)
--Metals production: Stainless and Nonstainless Steel Manufacturing (electric arc furnaces), Secondary Non-ferrous Metals, Taconite Iron Ore Processing, Iron and Steel Foundries, Integrated Iron and Steel Manufacturing, Ferroalloys Production, Secondary Lead Smelting, Integrated Iron and Steel Manufacturing, Primary Nonferrous—Zinc, Cadmium and Beryllium, Secondary Aluminum Production, Fabricated Metal Products Manufacturing, Fabricated Structural Metal Manufacturing, Nonferrous Foundries, Secondary Copper Smelting, and Primary Metal Products Manufacturing.
--Waste incineration: Hazardous Waste Incineration, Incineration (commercial and industrial solid waste), Municipal Waste Combusters, Incineration (on-site), Sewage Sludge Incineration, Medical Waste Incinerators, Incineration - Other Solid Waste, and Solvent Use: Surface Coating: Incinerators.
--Non-Utility Fuel Combustion: Industrial/Commercial/ Institutional Boilers & Process Heaters, Residential Heating: oil, Stationary Combustion Turbines, Residential Heating: coal, and Primary Aluminum Production. While Primary Aluminum Production might seem to fit better under the Metals Production category, in fact these emissions are from coal-fired boilers used to produce power at Alcoa's Warrick Operations in Indiana, and are not from the aluminum production process itself (according to personal communication from Scott Darling, Environmental Manager, Alcoa Warrick, July 27, 2009).

Source: U.S. Environmental Protection Agency, 2005 National Emissions Inventory (NEI) 072009, with revised estimates for incinerators provided by the Minnesota Pollution Control Agency. These estimates are subject to revision. Source categories amalgamated by authors.

Appendix E. shows a more detailed breakout of mercury emissions sectors, using NEI-designated source categories. The second-largest source category after coal-fired utility boilers is electric arc furnace steel production (3.4 tons). These emissions result from the use of mercury-contaminated scrap, as do the mercury emissions from iron and steel foundries (0.2 tons). In addition, metals production results in mercury emissions from secondary nonferrous metals (0.4 tons) and taconite production (0.4 tons).

The third-largest source in the 2005 NEI is Industrial/Commercial/Institutional Boilers and Process heaters. Another significant non-utility fuel combustion sources is residential heating with oil (0.6 tons). The fourth-largest source is hazardous waste incineration. Other significant incineration sources include Municipal Waste Combustors, Incineration: On-site, and Sewage Sludge Incineration. Portland cement manufacturing (1.4 tons) is the fifth-largest category. These emissions are the result of mercury in raw materials (primarily limestone and, in some cases, coal combustion residues). In the 2005 NEI, mercury emissions from chlor-alkali plants have been included in two categories—Chemical Manufacturing (1.0 tons) and Mercury Cell Chlor-alkali Plants (0.008 tons). Fluorescent lamp recycling (0.4 tons) and Municipal Landfills (0.3 tons) are the only sources greater than 0.2 tons not included in the categories described above.

The Michigan Department of Environmental Quality (MDEQ) has attempted to improve on the mercury emissions inventories developed under the NEI. Table DE shows estimates of mercury emissions in Michigan in 2002 according to MDEQ and to the NEI. The two inventories arrive at similar total emissions estimates for Michigan (within five percent of each other), and the two inventories both show that the largest sources in the state include coal combustion at electric utilities, cement manufacturing, various types of steel production, and

various non-utility fuel combustion sources. However, there are some notable differences in some estimates, and also some areas where MDEQ estimates significant emissions but the NEI does not include an estimate. The NEI estimate for electric utility coal combustion is roughly 1000 pounds higher than Michigan DEQ's estimate, and the NEI's estimates for mercury emissions from industrial/commercial coal combustion is 270 pounds higher and its estimate for cement production is 435 pounds higher. There are also significant differences for industrial/commercial wood combustion, biosolids incineration, municipal waste combustion, and cremation. Emissions from Michigan crematories are only five pounds annually according to the NEI, which bases its estimate on emissions factors derived from a small number of emissions tests. Michigan DEQ estimates emissions of 126-189 pounds, based on a mass balance model of the fate of dental amalgam fillings. While in many (but not all) cases, the NEI estimates are higher than the MDEQ estimates, there are a number of source categories for which MDEQ estimates significant emissions but the NEI does not provide an emissions estimate. These source categories include natural gas combustion, taconite production, emissions from mercury-containing products during use and disposal, burn barrels, and remediation of contaminated sites.

Table D: 2002 Estimates of Anthropogenic Hg Air Emissions in Michigan (pounds)

Emission Source	Michigan DEQ	NEI version 3
Coal Combustion		
Electric Utilities	2488	3477
Residential	1	0.01
Industrial/commercial	213	483
Oil Combustion		
Electric Utilities	51	51
Residential	36	51 distillate 6 kerosene
Industrial/commercial	2	23 Boilers & process heaters 1 stationary combustion turbines
Natural Gas Combustion		
Electric Utilities	9	--
Residential	95	--
Industrial/Commercial	19	--
Stationary Internal Combustion	234	--
Wood Combustion		
Electric Utilities	7	--
Residential/Outdoor Wood Boilers	8	--
Industrial/Commercial	5	151
Petroleum Refining	5	0
Residential LPG Propane Combustion	4	0
Total Fuel Combustion	3177	
Biosolids Incineration	285	88 Sewage Sludge Incineration
Municipal Waste	100	179 MWCs: small 29 MWCs: large
Hazardous Waste Incineration	41	2 HWI: on-site
Hospital Waste	3	0.1 Medical Waste Incinerators
Cement Manufacturing	694	1129 Portland Cement Mfing
Taconite processing	88	0
Lime Manufacturing	73	12
Dental Amalgam Manufacturing	4	53
Brick Manufacturing	1	0.4
Coke Production	3	
Thermometer Manufacturing	0	
Medical Waste Autoclave	NA	
Blast/BOF Steel Manufacturing	396	437 Integrated Iron and Steel
EAFs-primary metal production	31	Included in EAFs below

EAFs-secondary metal production	282	432 EAFs
Secondary metal production excluding EAFs	228-237	223 Iron and Steel Foundries
EAFs & EIFs in Secondary metal production	7-28	Included in EAFs above
AREA SOURCES		
Hg Containing Products		
Dental Amalgam	141	--
Auto switch/Auto shredding	117	--
Switches and relays (including thermostats)	96	--
Measurement and Control Devices	61	--
Consumer Use of Bulk Hg	20	--
Fluorescent Lamp Breakage	15	32.5
Fluorescent Lamp Recycling	4	0.01
Non-Fluorescent lamp Breakage	2	--
Waste Disposal		
Volatilization during solid waste collection and processing	887	--
Landfill volatilization	68	13
Burn Barrels	124	--
Cremation	126-189	10
Disposal of Bulk Hg to Clean Sweep Sites	7	--
Volatilization: land application of sludge	5	--
Contaminated Site Remediation	96	--
Mobile Sources	0.4-10.5	--
Emissions Categories Greater than One Pound Included in NEI but not in Michigan Inventory		
General Laboratory Activities		25
Asphalt Processing and Asphalt Roof Manufacturing		6.08
Gypsum Product Manufacturing		1.5
Total	7158-7269	6910

Source: Michigan Department of Environmental Quality's Mercury Strategy Staff Report. 2008. http://www.michigan.gov and U.S. Environmental Protection Agency, 2002 National Emissions Inventory (NEI) Version 3.

3.5 Conclusion: Sources of Mercury to the Great Lakes

While there are still significant uncertainties about emissions inventories and the fate and transport of mercury in the environment, the following conclusions can be made with confidence:

- Air deposition is the primary source of mercury to the Great Lakes.
- Mercury deposition to the Great Lakes originates from both natural and anthropogenic sources, and from sources within the Great Lakes states as well as from more distant sources within North America and sources overseas.
- The share of mercury deposition caused by nearby sources varies greatly depending on location. In some cases, high mercury deposition levels occur near to significant sources, where nearby sources (within 100 km, or within the same state) are thought to account for well over half of mercury deposition. In areas of the Great Lakes basin that are more distant from concentrations of large mercury emissions sources, the contribution from nearby sources is relatively small; for instance, CMAQ modeling indicates that over most of the Lake Superior basin, all North American anthropogenic sources account for less than 12.5 percent of mercury deposition.
- The closer a mercury emissions source of a given size and emissions profile is to the Great Lakes, the more deposition it contributes.
- Most of the individual emissions sources that contribute most mercury deposition to the Great Lakes are within the Great Lakes states.

- Coal-fired power plants are by far the largest-emitting sector within the Great Lakes states. While there is some uncertainty in emissions estimates, there is general agreement that after coal-fired power plants, the largest sources of mercury emissions within the Great Lakes states include metals production (primarily from the use of mercury-contaminated metal scrap, but also from virgin raw materials), waste incineration, cement production, fuel combustion at non-utility stationary sources, and mercury cell chlor-alkali plants.
- Modeling indicates that coal-fired power plants within the Great Lakes states account for a significant share of mercury inputs into the Great Lakes.
- The share of mercury deposition to the Great Lakes contributed by global sources is growing, as emissions in Asia and Africa grow while emissions in North America decline.

3.6 Expected Changes in Mercury Emissions and Deposition

3.6.1 Expected Changes in Nationwide Mercury Emissions

Federal regulations and evolving technology are expected to result in changes in the mercury emissions inventory within the United States over the next decade. For some sectors, federal regulations had not been in effect as of the most recent (2005) national emissions inventory, but have come into effect since. For other sectors, regulations have been promulgated, but not fully implemented. For still other sectors, EPA has proposed regulations, or expects to propose regulations. These existing and prospective regulations will be described in section 5; here, we summarize the impacts of anticipated regulatory and technological changes on mercury emissions through 2020.

In a presentation to the Great Lakes Binational Toxics Strategy Mercury Workgroup in December 2007, Chuck French of U.S. EPA's Office of Air Quality Planning and Standards provided projections of expected mercury emissions between 2002 (the most recent inventory at the time) through 2020.[44] These projections show a decline of approximately 50 percent in nationwide mercury emissions between 2002 and 2020, in addition to the 46 percent reduction that occurred between 1990 and 2002. However, two-thirds of the projected reduction from 2002 through 2020 was based on the anticipated impact of the Clean Air Mercury Rule (CAMR), a regulation meant to control mercury emissions from coal-fired utility plants beginning in 2010. However, in 2008 an Appeals Court found that U.S. EPA had acted improperly in developing CAMR, and vacated the regulation. U.S. EPA will develop a MACT standard, but it is not clear what level of control such a standard will achieve; CAMR was expected to achieve a 70 percent reduction nationwide.

Mercury emissions at electric arc furnaces are also expected to decline approximately 70 percent nationwide between 2002 and 2020 as a result of federal air emissions regulations and reductions in the mercury content of equipment that gets scrapped. Additional reductions are expected from federal regulations controlling mercury emissions from hazardous waste incinerators and federal regulations and plant closures or conversions of mercury-cell chlor-alkali plants. Further reductions in the mercury content of wastes are expected to lead to small additional reductions in mercury emissions from municipal waste combustors; emissions from these sources were already reduced more than 90 percent between 1990 and 2002. In addition, U.S. EPA has proposed regulation of emissions from Portland cement plants that would reduce mercury emissions from existing facilities by an estimated 11,600 to 16,250 pounds per year, or a reduction of 81 to 93 percent.[45] All of these nationwide sources are well represented in the Great Lakes states; therefore, it is anticipated that significant emissions reductions would occur in the Great Lakes states as a result of these regulations.

[44] French, Chuck, 2007. Reducing Mercury Emissions in the U.S.A.: Status of U.S. EPA Regulations and Other Actions. Presentation to the Great Lakes Binational Toxics Strategy Mercury Workgroup, Chicago, 12 December 2007.

[45] Estimates are from French, 2007, except for Portland Cement, which is from U.S. EPA, "Proposed Amendments To National Air Toxics Emission Standards For Portland Cement Manufacturing: Fact Sheet," 2009.

Additional significant reductions are expected from gold mining sources, but all of these sources are located in the Western U.S., with none in the Great Lakes states.

3.6.2 Impacts of Possible Future Changes in Emissions on Mercury Deposition

While there has been no modeling of the deposition impacts of reducing mercury emissions in the Great Lakes states only, there have been efforts to determine the impact of reducing mercury emissions nationwide. U.S. EPA performed dispersion modeling in 2005, using CMAQ, to evaluate the mercury deposition impact of emissions reductions from coal-fired electricity generating units (EGUs) required by different potential versions of the forthcoming CAMR. While CAMR has since been vacated, this modeling is still useful in demonstrating the potential impact of policies that achieve significant reductions in mercury emissions. U.S. EPA modeled mercury deposition under several different mercury emissions inventory scenarios, holding background natural and global emissions constant, and changing only the U.S. emissions inventory.

First, U.S. EPA compared deposition in 2001 with "baseline" 2020 deposition. Figure D shows modeled mercury deposition in 2001. Modeled mercury deposition is high in the Ohio River Valley, eastern Ohio, across Pennsylvania, especially in Western Pennsylvania, and in the far Western and Southeastern parts of New York, as well as in the major cities of the Great Lakes basin. It is generally elevated in the southern part and eastern portion of the Great Lakes states, in comparison with the northern and western part of the region. Nationwide, the maximum mercury deposition was an estimated 55 μg/m^2; the 90th percentile was 22 μg/m^2 and the median was 16 μg/m^2.

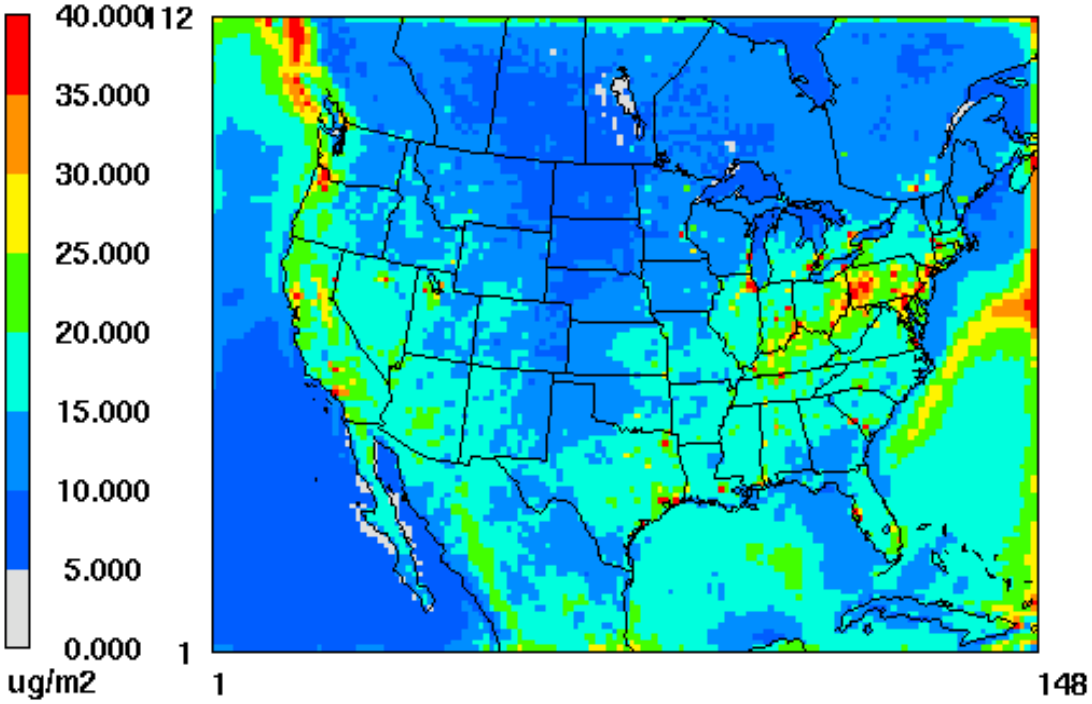


Figure D: 2001 Mercury Deposition, With Total U.S. Mercury Emissions of 115 Tons
Source: U.S. EPA, 2005c.[46]

[46] U.S. EPA 2005c. Technical Support Document for the Final Clean Air Mercury Rule, Air Quality Modeling. U.S. Environmental Protection Agency. March 2005. Access: http://www.epa.gov/ttn/atw/utility/aqm_oar-2002-0056-6130.pdf.

Under the 2020 baseline, U.S. mercury emissions would be lower than 2001 emissions by 27.7 tons, or 23.3 percent. Approximately half of these reductions would occur at coal-fired power plants as an incidental result of sulfur and nitrogen controls required under the Clean Air Interstate Rule (CAIR), and half would result from implementation of other regulations and predicted technology changes impacting other source sectors. CAIR, like CAMR, has subsequently been vacated by an Appeals Court. Figure E shows the reductions in mercury deposition that would occur as a result of reducing mercury emissions by 2020 under the baseline scenario. This figure shows that anticipated emissions reductions would reduce deposition by less than 2 $\mu g/m^2$ in much of the country, including most of the Northern and Western parts of the Great Lakes basin. However, mercury deposition would decline at least 2 $\mu g/m^2$ in much of Illinois, Indiana, Ohio, and the lower peninsula of Michigan, and by up to 16 $\mu g/m^2$ in much of the Ohio River Valley and Western Pennsylvania.

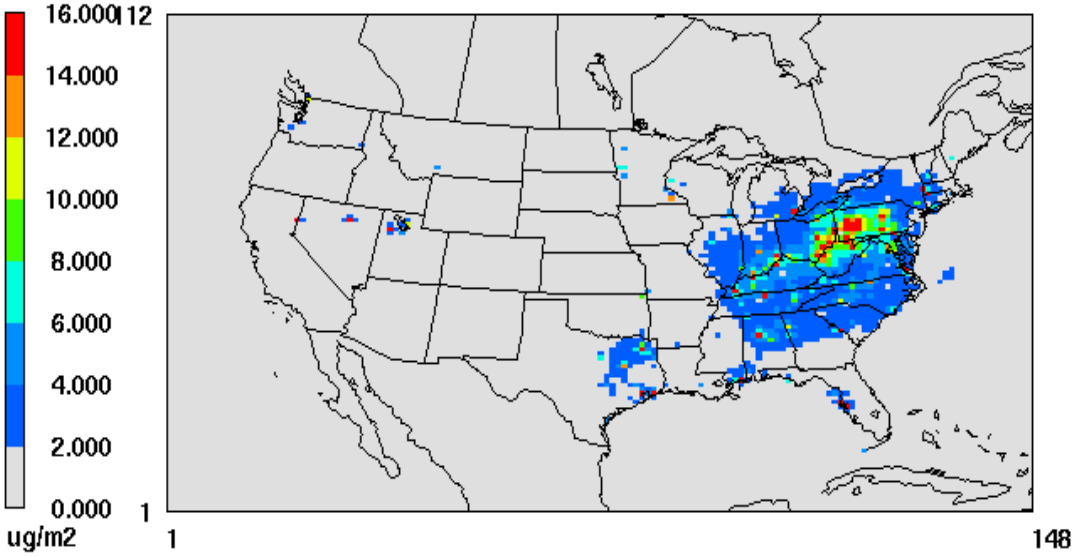


Figure E: Baseline 2020 Mercury Deposition Compared with 2001 Deposition (Results of a 28 ton Reduction in U.S. Emissions) Source: U.S. EPA, 2005c.[47]

Figure F shows the predicted mercury emissions in 2020 under the baseline emissions inventory scenario. The modeling shows that while anticipated emissions reductions would significantly reduce mercury deposition in the Eastern United States, particularly in the areas of highest deposition, mercury deposition would continue to be elevated in the southern part of the Great Lakes basin, and particularly in the vicinity of major cities, including Minneapolis, Milwaukee, Chicago, Indianapolis, Detroit, Cincinnati, and Pittsburgh.

[47] U.S. EPA 2005c. Technical Support Document for the Final Clean Air Mercury Rule, Air Quality Modeling. U.S. Environmental Protection Agency. March 2005. Access: http://www.epa.gov/ttn/atw/utility/aqm_oar-2002-0056-6130.pdf.

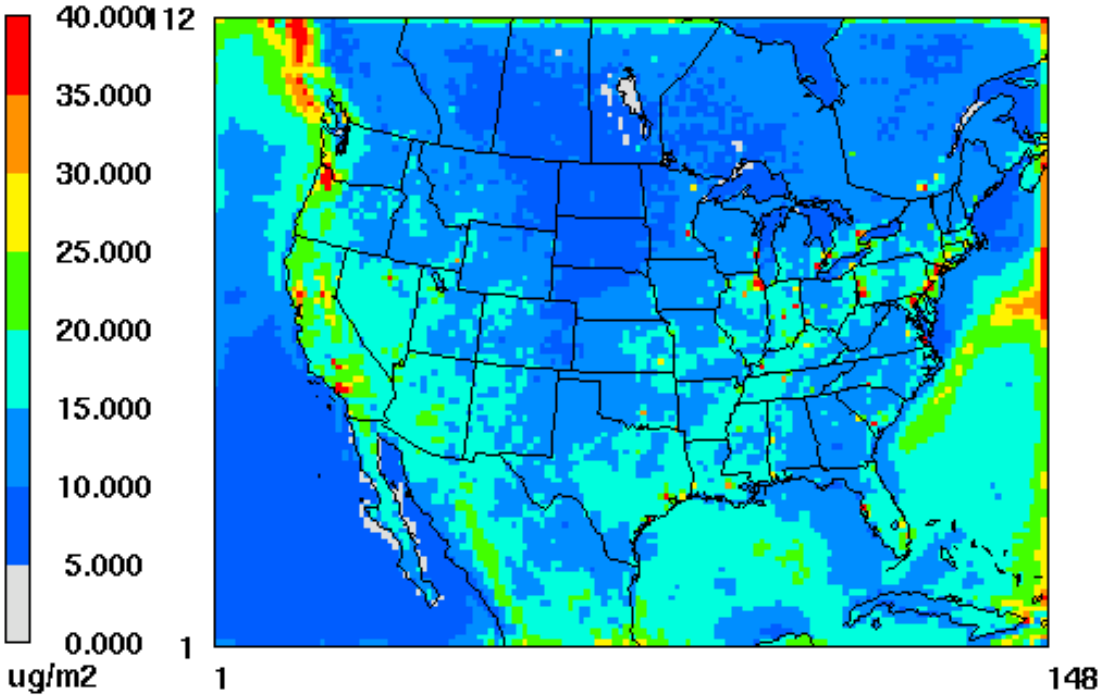


Figure F: 2020 Mercury Deposition, With U.S. Mercury Emissions Reduced 28 Tons from 2001 levels
Source: U.S. EPA, 2005c.[48]

U.S. EPA compared this 2020 baseline for mercury deposition with two additional scenarios:

- "CAMR Control Option 1," in which non-EGU emissions would be identical to the 2020 baseline, while EGU emissions would be 9.37 tons lower than under the 2020 baseline. Total emissions would be 37.07 tons lower than in 2001.
- "CAMR Control Option 2," in which non-EGU emissions would be identical to the 2020 baseline, while EGU emissions would be 13.59 tons lower than under the 2020 baseline. Total emissions would be 41.29 tons lower than in 2001.

Figures G and H show the additional reductions in mercury deposition under CAMR Option 1 and CAMR Option 2 that would occur relative to the 2020 baseline. In most of the country, deposition would be reduced less than one $\mu g/m^2$ by the reductions beyond the baseline. In the Great Lakes states, reductions of 1-4 $\mu g/m^2$ are predicted for a few scattered areas, primarily in Pennsylvania. According to the U.S. EPA modeling, the impact on mercury deposition of the additional emissions reductions beyond the 2020 baseline achieved by CAMR would be much less significant than the predicted reduction in deposition caused by the initial emissions reduction between 2001 and the 2020 baseline. This result occurs for two reasons. First, the incremental emissions reductions below the 2020 baseline are only 9-14 tons under the CAMR options, while the initial emission reduction between 2001 and the 2020 baseline is greater -- 28 tons. Second, U.S. EPA predicts that the CAMR options would result primarily in incremental reductions of elemental mercury, with relatively little of the reduction (14 -19 percent) coming from emissions of reactive gaseous mercury. By contrast, the anticipated reductions between 2001 and 2020 would be primarily (57 percent) from emissions of reactive gaseous mercury. Since reactive gaseous mercury emissions tend to deposit close to the source while elemental mercury has a long atmospheric residence time and therefore can be transported globally, reduced emissions of

[48] U.S. EPA 2005c. Technical Support Document for the Final Clean Air Mercury Rule, Air Quality Modeling. U.S. Environmental Protection Agency. March 2005. Access: http://www.epa.gov/ttn/atw/utility/aqm_oar-2002-0056-6130.pdf.

reactive gaseous mercury have a much bigger impact than equivalent reductions in elemental mercury emissions. U.S. EPA expects that initial efforts to control mercury emissions are likely to affect primarily reactive gaseous mercury emissions since emissions control equipment, for instance at coal-fired power plants, more easily capture this form of mercury. The CAMR control options would require deeper reductions in emissions from coal-fired power plants beyond the relatively easy-to-capture reactive gaseous mercury, leading to significant reductions in emissions of elemental mercury.

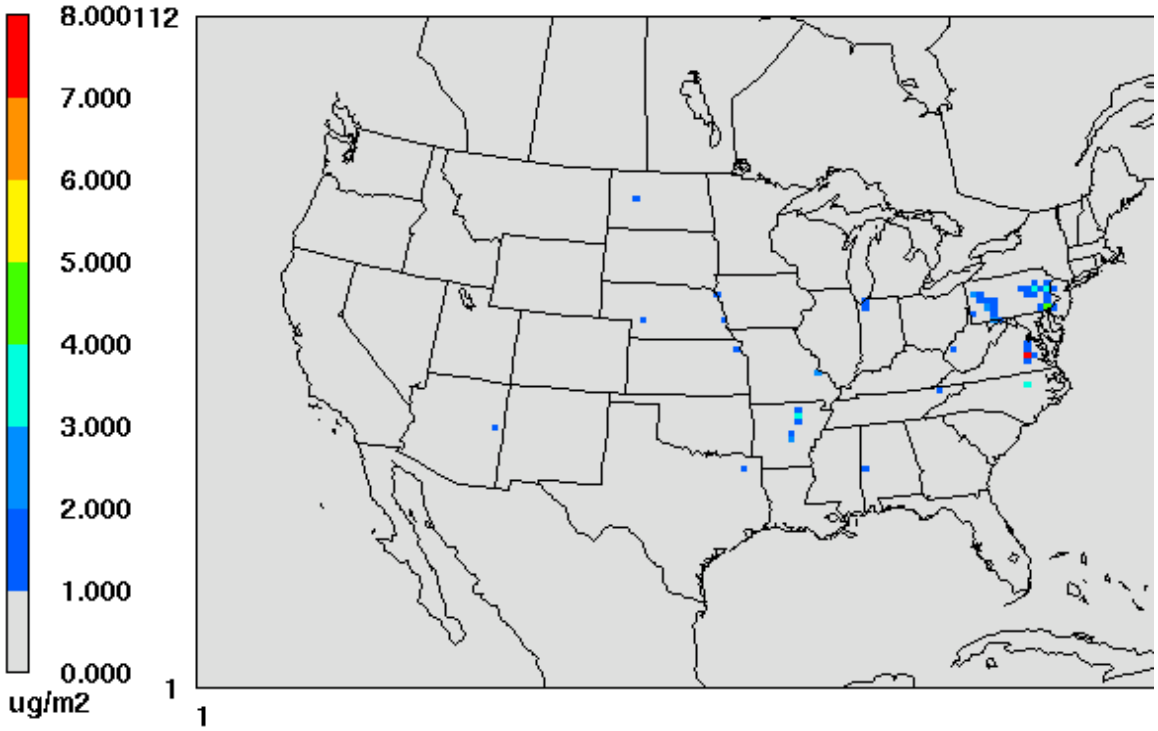


Figure G: CAMR Option 1 Compared with Baseline 2020 Mercury Deposition (Results of an Additional 9 ton Reduction in U.S. Emissions) Source: U.S. EPA, 2005c.[49]

[49] U.S. EPA 2005c. Technical Support Document for the Final Clean Air Mercury Rule, Air Quality Modeling. U.S. Environmental Protection Agency. March 2005. Access: http://www.epa.gov/ttn/atw/utility/aqm_oar-2002-0056-6130.pdf.

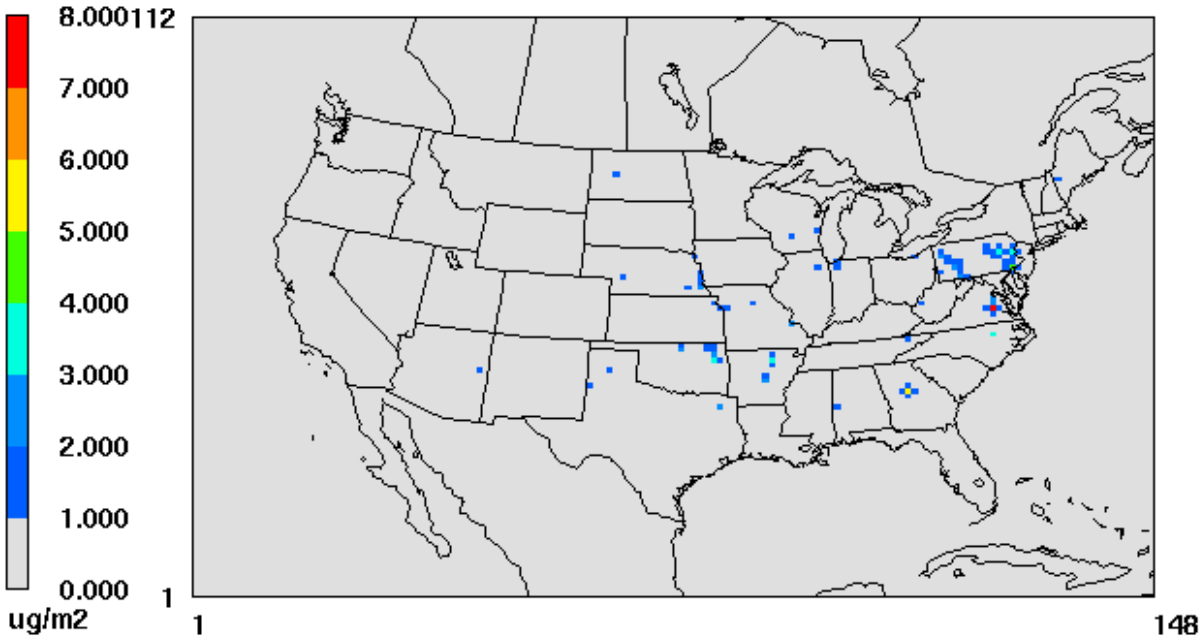


Figure H: CAMR Option 2 Compared with Baseline 2020 Mercury Deposition (Results of an Additional 14 ton Reduction in U.S. Emissions) Source: U.S. EPA, 2005c.[50]

3.7 Potential Global Benefits of Mercury Emissions Reduction within the Great Lakes States

In addition to the reductions in mercury deposition to the Great Lakes region that could result from reducing mercury emissions within the Great Lakes states, such reductions can have benefits beyond the Great Lakes states. The benefits beyond the Great Lakes states are most important when considering potential reductions in elemental mercury emissions, given elemental mercury's long atmospheric residence time and global atmospheric distribution. While reducing emissions of elemental mercury in the Great Lakes states is expected to have a relatively small impact on mercury deposition within the Great Lakes states themselves, [51] it will also have an impact on reducing mercury deposition to the oceans and to other places where mercury contamination is driven primarily by emissions from global sources rather than nearby sources.[52] While these global deposition reductions would be small, they would be spread out over a broad area and would benefit many people who consume mercury-contaminated seafood.

Global direct mercury emissions from all natural and anthropogenic sources and excluding re-emitted anthropogenic emissions, total approximately 4000 metric tons per year (see table A). Therefore, reducing

[50] U.S. EPA 2005c. Technical Support Document for the Final Clean Air Mercury Rule, Air Quality Modeling. U.S. Environmental Protection Agency. March 2005. Access: http://www.epa.gov/ttn/atw/utility/aqm_oar-2002-0056-6130.pdf.

[51] While most modeling indicates that mercury deposition in most cases in driven by reactive gaseous mercury, some studies show that elemental mercury concentrations in the atmosphere can contribute appreciably to mercury loading to some water bodies, through gaseous transfer. For instance, in their work estimating mercury fluxes into and out of Lake Ontario, Lai et al. reported that the largest fraction of total deposition to the lake surface was actually attributable to elemental mercury. Elemental mercury deposition was estimated to be 300 kg/year, with 410 kg of emissions, for a net gas exchange of 110 kg/yr emitted. (S. Lai, T.M. Holsen, Y. Han, P.P. Hopke, S. Yi , Pierrette Blanchard, J.J. Pagano and M. Milligan. Estimation of mercury loadings to Lake Ontario: Results from the Lake Ontario atmospheric deposition study (LOADS). Atmos. Environ. 41:8205-8218, 2007.) Moreover, a large source of elemental mercury emissions can cause significant mercury deposition in the vicinity of the source; Landis et al. estimated that 40 percent of the local gaseous dry mercury deposition caused by a chlor-alkali plant resulted from elemental mercury emissions. See M.S. Landis, G.J Keeler, K.I. Al-Wali and R.K. Stevens. Divalent inorganic reactive gaseous mercury emissions from a mercury cell chlor-alkali plant and its impact on near-field atmospheric dry deposition. Atmos. Environ., 38:613-622.

[52] S. Lindberg, R. Bullock, R. Ebinghaus, D. Engstrom, X. Feng, W. Fitzgerald, N. Pirrone, E. Prestbo and C. Seigneur. A Synthesis of Progress and Uncertainties in Attributing the Sources of Mercury in Deposition. Ambio, 36(1):19-32, 2007.

mercury emissions within the Great Lakes states by an additional ten tons, for example, beyond the reductions that will be achieved through federal regulations, would reduce global primary mercury emissions by approximately 0.25 percent. Ten tons represents more than one-quarter of 2005 mercury emissions within the Great Lakes states. While such a reduction would not be detectable in global mercury deposition monitoring, it would be a real reduction and would represent a small contribution from the Great Lakes states towards reducing global mercury contamination problems. Only through numerous similar contributions from many different regions can the global mercury problem be addressed. Moreover, efforts in the Great Lakes could help inspire similar reduction efforts in other places, helping to promote global reductions that will reduce mercury deposition to the Great Lakes and globally.

4. SELECTION OF MERCURY-EMITTING SECTORS

4.1 Criteria for Selecting Emission Sources Addressed in the Strategy

The Great Lakes Regional Collaboration has called for a Great Lake Mercury Emissions Reduction Strategy that reduces emissions from "new and existing sources whose mercury emissions have not been regulated," and from sources that have been regulated but nonetheless present opportunities for additional reduction. This Strategy uses the following criteria to identify source sectors that should be evaluated to determine whether there are good opportunities for reduction:

4.1.1 Source Sectors with the Highest Total Emissions

According to the 2005 National Emissions inventory (see Appendix G), the largest mercury emissions sources in the Great Lake States are:

- Coal-fired utility boilers
- Electric arc furnaces
- Industrial/commercial and institutional boilers
- Hazardous waste incinerators
- Portland cement manufacturers
- Chemical Manufacturing
- Municipal waste combustors
- Residential heating with distillate oil
- Secondary Nonferrous Metals
- Fluorescent lamp breakage
- On-site Incineration
- Taconite Iron Ore Processing

4.1.2 Source Sectors that Might be Expected to Have High Deposition within the Great Lakes Basin (due to speciation profile or high local emissions impact because of large individual sources)

Modeling indicates that among North American source sectors, coal-fired utility boilers have the largest impact on mercury deposition within the Great Lakes states. Incineration sources may have a larger deposition impact than would be predicted by their total emissions, because they tend to emit a higher percentage of oxidized mercury than other sources.

4.1.3 Source Sectors with Potential for Future Emissions Growth

Most source sectors are expected to experience either little growth in mercury emissions over the coming decades, or actual reductions as the result of existing state and federal regulation or changing technology. Crematories are a significant exception, because of expected growth in cremation versus burial and because improved dentistry means more people die with teeth intact (and therefore with mercury fillings in their mouths). Cremation is not a significant emissions source in the National Emissions Inventory, but some state

inventories indicate that it is a significant source. The Strategy addresses crematories in the context of evaluating mercury emissions caused by the use and disposal of mercury-containing products.

Once sources have been selected based on the above criteria, we evaluate them to determine whether it is prudent to recommend action by the Great Lakes states to reduce emissions:

- Are emissions from the sector already being addressed by federal or basin-wide state regulations or voluntary efforts?
- Do states have the ability to go beyond existing or forthcoming regulations/programs?
- Are there cost-effective opportunities for additional reduction?

Based on evaluation of these criteria, this report makes recommendations for some sectors but not others.

4.2 Priority Emission Sources

For the purpose of this strategy, it is fruitful to aggregate some source categories together in order to explore whether emissions can be reduced through approaches that can address these categories simultaneously. Based on the above criteria, we have decided to evaluate the following broad sector categories (see also table C):

- Utility boilers
- Metals production
- Cement production
- Waste incineration
- Non-Utility fuel combustion
- Mercury cell chlor-alkali plants
- Mercury emissions related to product use and disposal

5.0 ADDRESSING PRIORITY MERCURY EMISSIONS SOURCES:

5.1 Fossil Fuel Electric Power Generation

5.1.1 Background

Fossil fuel electric power generation can be divided into three main categories of fuel combustion: coal combustion, fuel oil combustion and natural gas combustion. Fuel oil combustion can be sub-divided into residual oil, distillate oil and lighter fractions. Fossil fuel combustion is used to generate super-heated steam directed to a steam turbine, which in turn produces electricity to be supplied to the electrical grid.

Steam under varying pressures and temperature can be directed to a steam turbine for electricity or in combination to industrial processes elevating the efficiency of the fuel burning process. These uses of steam are classified as electrical co-generation facilities and are common with natural gas-fired turbines capable of producing electricity from the turbine and also using the waste heat applied to a steam turbine.

The emission of mercury from this source category is from the liberation of fuel-bound mercury in the combustion process. The mercury concentration of fuel is best expressed as pounds per million Btu of fuel (lb/mmBtu) because oil and coal do not have the same characteristics with respect to caloric value. Also, coal ranks are broadly classified as anthracite, bituminous, subbituminous, and lignite. These classifications are made according to the coal's heating value as well as relative amounts of fixed carbon, volatile matter, ash, sulfur, and moisture. [53]

[53] US EPA AP-42, External Fuel Combustion

In 1997, the U.S. EPA's Mercury Study to Congress reported that the annual emissions of mercury from utility boilers for oil, natural gas and coal were 50.96 tons per year. Coal fired utilities accounted for an estimated 99 percent of these emissions.[54] Mercury concentrations have been better studied in coal than in oil or natural gas. Therefore, there is some uncertainty about emissions from oil and natural gas combustion, but it is nonetheless clear that these emissions are much lower than emissions from coal combustion.

5.1.1.a. Processes that emit mercury

In 2007, a total of 1,046.4 million short tons of coal were consumed by utility boilers producing steam for the generation of electricity. Coal accounted for 71.5 trillion Btu per day within the electric utility sector, while all petroleum products accounted for 3.7 trillion Btu per day and natural gas accounted for 19.3 trillion Btu per day.[55] Based upon the data of fuel usage per day and the emissions reported from the electric utility sector in the Mercury Study to Congress, the emissions of mercury are dominated by the burning coal.

Mercury emissions liberated from the burning of coal can be divided into three separate species: particle-bound mercury, oxidized mercury and elemental mercury. The form of mercury released from the electric utility stack is influenced by the pollution control equipment employed, the rank of coal burned (bituminous, subbituminous or lignite), and the amount of chlorine associated with the coal rank. Once emitted, the form of mercury influences its deposition. Oxidized and particle-bound mercury have been shown to deposit nearby the source, within 50 km, while elemental mercury is thought to remain in the atmosphere for up to two years. A study conducted by Keeler, et. al.[56] using back trajectory models, examined the wet deposition of mercury at various sites and identified mercury deposition occurring within 100 km of several coal-fired power plants. Ultimately, the deposition of mercury to the Great Lakes basin will be based upon the species and quantity of mercury in the atmosphere. Studies have been performed and are on-going to determine the atmospheric transformation of mercury after it has been emitted.

Bituminous coal can have a chlorine content ranging from 850 to 1250 ppm, while subbituminous and lignite coals can have a chlorine content as low as 75 to 200 ppm.[57] Chlorine content has been found to be related to a greater degree of control by conventional pollution control devices because flue gas mercury is oxidized to mercuric chloride and so acts more like a particle and is captured by conventional pollution control devices. Also, devices such as selective catalytic reduction (SCR), employed to control nitrogen oxides, have been found to have the additional effect of oxidizing mercury and leading to greater control, particularly when used with bituminous coals. Mercury which exists in the elemental form stays as a gaseous pollutant and is not captured by particle control devices. The halogen content of the fuel and the addition of halogens have been employed as control strategies and are discussed in item c.

5.1.1.b. Sector mercury emissions, nationally, and within Great Lakes

The U.S. EPA's Mercury Study to Congress reported nationwide emissions of mercury of 50.96 tons per year for all fuel types, with the Great Lakes States contributing 18.15 tons per year or 35.6 percent of the nationwide emissions.

Based upon the Information Collection Request (ICR) conducted in 1999 by the U.S. EPA, mercury emissions nationally were extrapolated at 48 tons per year for coal fired utilities. The ICR process required stack testing

[54] U.S. EPA, Office of Air Quality Planning and Standards, Mercury Study to Congress, Appendix A, Table A-1
[55] Department of Energy, Energy Information Administration, April, 2008
[56] Keeler, G, et. al. Sources of Mercury Wet Deposition in Eastern Ohio, Environmental Science and Technology, 40,5874-5881, 2006
[57] U.S. EPA HAP Working Group, West Associates presentation, 9/2/2002

from over 80 electric utilities representing varying boiler configurations, pollution control equipment and fuel type. Every coal-fired electric utility in the nation was required to record the quantity of coal burned and mercury content of the coal for one year. Once the stack test data were recorded, emission factors were established for like facilities using similar control devices and fuel and this data was extrapolated to all electric utilities in the nation.

Sources within the Great Lake states were calculated to contribute 37 percent of the nation's coal-fired utility boiler mercury emissions using the 1999 data. National Emission Inventory data for 2002 had mercury emissions of 38,016 pounds per year.

Table E: Mercury Emissions Attributed to Coal-fired Utilities

State	Pounds Per Year (Mercury Study data)	Pounds Per Year (1999 ICR data)	Pounds Per Year (2002 NEI data)
Illinois	2,790	5,989	7,733
Indiana	4,840	4,883	5,475
Michigan	3,804	3,082	3,477
Minnesota	1,482	1,262	1,473
New York	2,664	1,027	960
Ohio	7,964	7,109	7,253
Pennsylvania	10,266	9,959	9,493
Wisconsin	2,344	2,263	2,152
Total	**36,154**	**35,574**	**38,016**

Emissions of mercury from oil fired units were estimated to be 148 pounds in the Mercury Study and 198 in the 2002 NEI data.

5.1.1.c. Control Approaches

In the flue gas of fossil fuel electric power utilities, mercury can exist in three forms - elemental mercury, oxidized mercury or particle bound mercury. Mercury in the oxidized form is water-soluble and behaves as a particle. These characteristics make it ideal to be captured in wet and dry scrubber technology, fabric filters, and (to a lesser extent) electrostatic precipitators (ESPs), with the efficiency being greater in fabric filters as compared to ESPs. The use of selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) for the control of nitrogen oxides have been found to increase the percentage of oxidized mercury to elemental mercury in the flue gas and increase overall control efficiency from traditional pollution equipment, particularly when used with bitumous coals. Research funded by the U.S. Department of Energy (DOE) on pilot and full scale testing showed elemental oxidation across the SCR catalysts of 75 to 90 percent conversion of elemental to oxidized mercury.[58]

[58] International Conference on Air Quality, 9/2007. Blythe, G. et. al., Mercury Oxidation Catalysts for Enhanced Control by Wet FGD, URS Corporation, NETL, DOE

At present, the most commonly-used strategy to reduce mercury emissions from coal fired power plants has been the use of controls for sulfur dioxide (e.g., scrubbers), nitrogen oxides (e.g., SCR) and particulate matter (e.g., fabric filters, ESP). The most promising mercury-specific control has been determined to be the injection of activated carbon (AC) upstream of particle control devices. This technology was first introduced for the control of mercury in municipal waste combustor facilities. The use of halogenated AC, most notably bromine, has greatly improved the capture efficiency of AC alone.[59]

DOE-funded research has reported the economic costs of applying AC at various sites throughout the nation, and has demonstrated a trend of decreasing cost as technology improves. The amount of mercury reduction and the cost per pound of mercury reduction depend greatly on the rank of coal burned and any additional costs incurred to upgrade particle pollution control devices to accommodate the additional particle loading. DOE's 1999 baseline estimates were that the incremental costs of controlling mercury would vary from $50,000/lb to $70,000/lb of mercury removed. Based on testing conducted at six different units in 2004, DOE found that control costs were substantially lower than baseline estimates at most, but not all, units. Costs for 70 percent mercury capture, including the costs of dealing with mercury impacts on control device byproducts, ranged from $19,200/lb to $149,000/lb, with the second highest control costs coming in at $69,900, and all others below $50,000. DOE also estimated that the increased electricity cost resulting from the use of AC would be from 0.14 to 3.92 mills per kilowatt-hour (0.014 to 0.392 cents per kilowatt-hour). The unit with the highest incremental cost per pound of mercury removed was a unit that combusts bituminous coal and that had a high (50 percent) baseline rate of removal prior to activated carbon injection. Mercury emissions from bituminous coals are more easily controlled by existing control devices, due to the higher mercury chloride concentrations. Therefore, the baseline concentrations of mercury were relatively low, making the cost per additional pound removed by AC injection higher than at the other facilities.[60] The study found that western subbitmuminous coal, which has very low chlorine levels and emits higher amounts of elemental mercury was more cost-effectively controlled with AC impregnated with bromine.[61]

DOE's long-term goal is to develop advanced mercury control technologies to achieve 90 percent or greater capture that would be available for commercial demonstration by 2010. The U.S. Department of Energy's National Energy Technology Laboratory reports that nearly 90 full-scale activated carbon injection (ACI) control systems have been ordered by U.S. power generators. The ACI systems have the potential to remove over 90 percent of the mercury in most applications and at a cost that can be less than $10,000 per pound of mercury removed.[62]

Other options to reduce overall mercury emissions from coal burning units are to increase the efficiency of units through either greater use of cogeneration of electrical energy and steam sales or the introduction of integrated gasification combined cycle (IGCC) technology. Another technology also believed to match the efficiency of IGCC is the introduction of ultra-supercritical steam boilers. A modern supercritical steam boiler operating at

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[59] International Conference on Air Quality, 9/2007. Sid Nelson Jr., Ronald Landreth, Ph.D., Xin Liu, Ph.D., Zhong Tang, Ph.D., & Jon Miller, Power-Plant Mercury Control Results with Brominated PAC and ESPs.

[60] Jones, A. et al. DOE/NETL's Phase II Mercury Control Technology Field Testing Program: Preliminary Economic Analysis of Activated Carbon Injection, Environmental Science and Technology, 41, 1365-1371, 2007. This study also evaluated the costs of 50% control at all six units, and the costs of 90% control at three units. The cost per pond of mercury captured was found to be higher for 50% control than for 70% control, while 90% control was similar in cost per pound to 70% control.

[61] Jones, A. P.; Hoffmann, J. W.; Smith, D. N.; Feeley, T. J.; Murphy, J. T. *DOE/NETL's Phase II Mercury Control Technology Field Testing Program: UPDATED Economic Analysis of Activated Carbon Injection.* Prepared for the U.S. Department of Energy, May 2007. T.J Feeley, personal communication, April 14, 2009.

[62] Feeley, T.J.; O'Palko, B.A.; and Jones, A.P., 2008. Developing mercury control technology for coal-fired power plants - from concept to commercial reality. Main Group Chemistry. 7(3):179-169.

3,500 psig (pounds per square inch gauge) has an efficiency of 8,900 Btu/kilowatt-hour. Ultra-supercritical units operate at 4500 psig with an efficiency of 8,150 Btu/kilowatt-hour and IGCC units would be comparable at 8,167 Btu/kilowatt-hour.[63] Subcritical units currently employed operate at 2,400 psig with an efficiency of 9,500 Btu/kilowatt-hour.

This section focuses primarily on control approaches that involve the use of mercury emissions control technology for coal-fired power plants. However, mercury emissions from this sector can also be reduced by minimizing the combustion of coal for electricity production. Therefore, polices that reduce electricity use by promoting energy efficiency, that make more efficient use of fossil-fuel resources (for instance, through combined heat and power), or that reduce the share of electricity production accounted for by coal combustion are also options for achieving mercury reduction. Such approaches have broader benefits than just mercury reduction, since they reduce other harmful emissions associated with coal combustion, including greenhouse gases, sulfur dioxide, and oxides of nitrogen, along with the environmental impacts of coal mining and coal combustion waste disposal.

A variety of resources are available to states that wish to evaluate policies that could be used to promote energy efficiency and renewable energy. A *National Plan for Energy Efficiency*, developed in 2006 by a group of state regulators, utilities, and industry with assistance from the U.S. Department of Energy and U.S. EPA, includes many recommendations for action by state governments, under the following themes:

- "Recognize energy efficiency as a high-priority energy resource.
- Make a strong, long-term commitment to implement cost-effective energy efficiency as a resource.
- Broadly communicate the benefits of and opportunities for energy efficiency.
- Promote sufficient, timely, and stable program funding to deliver energy efficiency where cost-effective.
- Modify policies to align utility incentives with the delivery of cost-effective energy efficiency and modify ratemaking practices to promote energy efficiency investments."[64]

The National Renewable Energy Laboratory and the Alliance to Save Energy, in partnership with U.S. Department of Energy, U.S. EPA and state stakeholders, has evaluated best practices for state clean energy policies. Policies evaluated include contractor licensing, equipment certification, generation disclosure, grants and rebates, interconnection, line-extension analysis, mandatory and voluntary green power purchasing, net metering, public benefit funds, renewable energy access laws, renewable energy production incentives, renewable portfolio standards, and tax incentives.[65]

5.1.2 Existing and Prospective Federal Regulation

On March 15, 2005 EPA announced the final Clean Air Mercury Rule (CAMR). CAMR limited mercury emissions from new and existing coal-fired electric steam generating units, and created a market-based cap-and-trade program that intended to permanently cap utility mercury emissions nationwide in two phases. The first phase cap was 38 tons beginning in 2010; the second phase cap set at 15 tons beginning in 2018. EPA believed these mandatory declining caps would ensure that mercury reduction requirements were achieved and sustained. On May 18, 2005, EPA promulgated Emission Guidelines and Compliance Times for Coal-Fired Electric Steam Generating Units. [66] Pursuant to 40 CFR 60.4141, all States were required to submit to the Administrator their designated mercury allowances for each coal-fired electric steam generating unit by November 15, 2006. Regardless of whether a State was adopting the federal program or creating its own State

[63] Khan, Sikander, U.S. EPA, Presented at the DOE/NETLMegaSymposium, Baltimore, Maryland, August 2006

[64] *National Plan for Energy Efficiency: A Plan Developed by More than 50 Leading Organizations in Pursuit of Energy Savings and Environmental Benefits through Electric and Natural Gas Energy Efficiency.* U.S. Environmental Protection Agency and U.S. Department of Energy, July 2006.

[65] Elizabeth Brown and Sarah Busche, *State of the States 2008: Renewable Energy Development and the Role of Policy.* National Renewable Energy Laboratory. NREL/TP-670-43021 October 2008

[66] http://www.epa.gov/ttn/atw/utility/fr18my05.pdf, 70 Fed-Reg 28606-28700.

control plan, all States had to require applicable sources to limit mercury emissions at or below levels which meet the allocations designated in 40 CFR 60.4140

The Clean Air Mercury Rule (CAMR) is no longer in effect. On February 8, 2008, the United States Court of Appeals for the District of Columbia Circuit vacated the CAMR. On May 20, 2008, the Appellate court rejected U.S. EPA and the electric utility industry's bid to reconsider that decision. On October 17, 2008 the U.S. EPA requested the U.S. Supreme Court review the Court of Appeals February 8, 2008 decision and the rejection of the Appellate Court to overturn the ruling. In February of 2009, U.S. EPA withdrew a request for US Supreme Court review of the Court of Appeals' decision, and the Supreme Court rejected a separate petition for review by the Utility Air Regulatory Group. As a result, U.S. EPA will need to implement the requirements of section 112(d) of the Clean Air Act and proceed with a Maximum Achievable Control Technology standard for coal- and oil-fired electric utilities. As a result, U.S. EPA will need to implement the requirements of section 112(d) of the Clean Air Act and proceed with a Maximum Achievable Control Technology standard for coal- and oil-fired electric utilities. U.S. EPA is under a court ordered deadline to propose a standard by March 16, 2011, and to complete rulemaking by November 16, 2011.

5.1.3 Existing and Prospective State Regulation

States had the option to either adopt the CAMR's model rule or promulgate their own State rule. As a result, many states developed rules meant to control mercury emissions from coal-fired power plants. Many of these rules cannot function given that CAMR is no longer in effect; however, some states developed rules that can function independently of CAMR. All state rules needed to meet the basic requirements of the model rule and assure the mercury reductions pursuant to 40 CFR 60.4141 were met. Below is a table of the Great Lakes States who pursued their own independent state rule or who developed a state rule that could function only in conjunction with a federal CAMR.

Table F

State	Rules	Compliance Dates	Standard and/or Percent Reduction
Illinois	Adopted State Rule	**New -** upon commencement of operation **Existing** **1.)** 2009 or **2.)** Averaging demonstration between same ownership facilities until 2014	**New -** 0.008 lbs/GWh or 90% control **Existing** - **1)** - 0.008 lbs/GWh or 90% control or **2)** - 0.020 lbs/GWh or 75% control
Indiana	Adopted Clean Air Mercury Rule-based State Rule (cannot function without CAMR)	NA	NA
Michigan	Proposing State Rule	**New -** upon commencement of operation **2015 –** Without Multi-pollutant option Multi-pollutant Option 1st - 2015	**New -** 0.008 lbs/GWh or 90% control **Without Multi-pollutant option** 0.008 lbs/GWh or 90% control **Or** **Multi-pollutant** 1st - 75% control
Minnesota	Adopted State Rule Adopted State Strategy	**Existing:** Specific facilities >300 MW Compliance date – 2015 70 – 90% reduction at remaining facilities emitting greater than 5 lb/yr	90 % reduction 70-90% reduction
New York	Adopted State Rule	**New -** upon commencement of operation **Existing** **1st** 2010 **2nd** 2015	**New -** 0.6 lbs/Tbtu (0.006 lbs/GWh) equivalent **1st** Emission Cap- 50% statewide reduction **2nd** 0.6 lbs/Tbtu - 90%

Ohio	Adopted Clean Air Mercury Rule-based State Rule (cannot function without CAMR)	NA	NA
Pennsylvania	Adopted State Rule that was recently struck down by the Pennsylvania Commonwealth Court	**New -** upon commencement of operation **Existing** **1st** 2010 **2nd** 2015	**New -** 0.011 lbs/GWh **Existing** - **1st** - 0.024 lbs/GWh or 80% control **2nd** - 0.012 lbs/GWh or 90% control
Wisconsin	Adopted State Rule	**1.)** 2010 - First Compliance Date **2.) 2015 - Without Multi-pollutant option** **3.) Multi-pollutant Option** **1st** - 2015 **2nd** -2018 **3rd** -2021	**1.)** 40% Reduction from 2007 Emission levels **2.) Without Multi-pollutant option** 0.008 lbs/GWh or 90% control **3.) With Multi-pollutant** 1st - 0.019 lbs/GWh or 70% control 2nd - 0.013 lbs/GWh or 80% control 3rd - 0.008 lbs/GWh or 90% control

The **Multi-pollutant Alternative** for Michigan and Wisconsin is for large electric generating units to delay the 90 percent mercury emission reduction standard if the electric generating unit reduces nitrogen oxides and sulfur dioxide emissions beyond those currently required by federal and State regulations. Owners and operators must designate which large units will follow the multi-pollutant option to receive additional years to achieve a 90 percent mercury emission reduction standard.

5.1.4 State and Federal Voluntary Programs Affecting Emissions from this Sector

There have been no voluntary programs to promote installation of emissions control technology in this sector. This report will not attempt to enumerate the many state programs that promote more efficient use of electricity or the use of less-polluting electricity production. We just note here that many states are already pursuing a variety of voluntary and regulatory efforts to improve the efficiency of energy use and production, including technical assistance and training, state codes, and incentives for utility companies to invest in customer energy efficiency, along with efforts to promote renewable energy, including through tax credits, grants, and renewable portfolio standards.[67] While these efforts are not thought of as primarily mercury-reduction policies, they can have important mercury reduction benefits. For instance, Illinois is implementing a Sustainable Energy Plan, which includes a renewable portfolio standard and a renewable portfolio standard. An

[67] Information about individual state programs that promote renewable energy, including renewable portfolio standards, is available at http://www.dsireusa.org/summarytables/reg1.cfm?&CurrentPageID=7&EE=0&RE=1, and information about about state incentives for renewable energy and energy efficiency is available at http://www.dsireusa.org/Index.cfm?EE=0&RE=1

evaluation of this plan estimated the reductions in emissions of SO2, NOx, mercury, and CO2 that it would cause from 2007 through 2013. Estimated benefits during this period include mercury emissions reductions of 760 pounds, of which 238 pounds would occur in Illinois.[68]

5.1.5 Recommendations for State Action

- Recommendation 1: States that are developing or implementing regulations limiting mercury emissions from coal-fired power plants should continue to do so within their proposed schedule.
- Recommendation 2: States should support federal efforts to regulate mercury emissions by providing data and analysis of mercury emissions reductions that have been achieved under state programs and that are projected to be achieved in the future.
- Recommendation 3: States should support regulations that achieve mercury emissions incidentally to other environmental objectives, such as the Clean Air Interstate Rule.
- Recommendation 4: If federal regulations limiting mercury emissions from coal-fired power plants have not been proposed by the end of 2013, states that have not already done so should consider implementation of their own regulations to achieve mercury emissions reductions.
- Recommendation 5: When considering implementation of policies that promote energy efficiency and renewable energy, states should take into account the potential benefits that such policies will have for mercury emissions reduction, along with the other benefits and costs of such policies.

5.2 Industrial, Commercial & Institutional Boilers

5.2.1 Background

Sources within the Industrial source category are large steam boilers used to generate steam for processes or electricity. Commercial and Institutional boilers provide heat and/or power at educational institutions and office buildings. This grouping of boilers is regulated as the Industrial, Commercial and Industrial Boiler sector (ICI boiler). Electricity generated at these sites is typically for in-house use and not for sale to the electric grid. According to the 1997 Mercury Study to Congress, the annual emissions of mercury from the ICI boilers were 28.4 tons per year for coal and oil firing. Of the total emissions reported by the Mercury Study, coal fired boilers accounted for 73 percent of the emissions and petroleum oil accounted for the other 27 percent.[69]

This sector includes boilers ranging in size from <10 mmBtu/hr to over 250 mmBtu/hr. Many of the large industrial boilers are located at paper mills, chemical plants and refineries burning fossil fuels, waste products or by-products. Some of the waste and by-products, (such as bark and polymers) contain little or no mercury. Other waste products, such as black liquor effluent in the pulp and paper industry, have mercury contamination. This specific waste is regulated under another source category, known as recovery boilers under Subpart MM of §112(c) of the Clean Air Act Amendments. The source of mercury emissions from ICI boiler would be those industries burning coal, petroleum products and waste by-products. Section a.) will identify which major processes burn coal or petroleum products.

On September 13, 2004, the U.S. EPA promulgated the final rule for the National Emission Standards for Hazardous Air Pollutants for Industrial/Commercial/Institutional Boilers and Process Heaters.[70] The following

[68] U.S. Department of Energy. *Clean Energy and Air Quality Integration Fact Sheet Series: Illinois—High Level Commitment Key to Air Quality Success.* NREL/FS-640-42165 DOE/GO-102007-2503, September 2007.
[69] U.S. EPA, Office of Air Quality Planning and Standards, Mercury Study to Congress, Appendix A, Table A-4
[70] National Emission Standards for Hazardous Air Pollutants for Industrial/Commercial/Institutional Boilers and Process Heaters: Final Rule, Federal Register Volume 69, No, 176, September 13, 2004.

source categories were identified as those which maintain steam boilers capable of emitting hazardous air pollutants, including mercury:

Table G

NAICS	SIC	
211	13	Extractors of crude petroleum and natural gas.
321	24	Manufacturers of lumber and wood products.
322	26	Pulp and paper mills.
325	28	Chemical manufacturers.
324	29	Petroleum refineries, and manufacturers of coal products.
316, 326, 339	30	Manufacturers of rubber and miscellaneous plastic products.
331	33	Steel works, blast furnaces.
332	34	Electroplating, plating, polishing, anodizing, and coloring.
336	37	Manufacturers of motor vehicle parts and accessories.
221	49	Electric, gas, and sanitary services.
622	80	Health services.
611	82	Educational services.

5.2.1.a. Processes that emit mercury

The emission of mercury from this source category is from the liberation of fuel bound mercury in the combustion process. In 2005, the ICI boiler sector consumed a total of 8,100 trillion Btu. Under the background documentation for the ICI rulemaking, the U.S. EPA identified 40,000 industrial boilers. According to a study conducted by Energy and Environmental Analysis Inc., there are 19,500 industrial boilers larger than 10 mmBtu/hr, including more than 1,300 larger than 250 mmBtu/hr. Commercial facilities have 26,000 boilers larger than 10 MmBtu/hr but only about 130 larger than 250 mmBtu/hr. The vast majority of commercial boilers are smaller than 10 mmBtu/hr. Overall, the size of the average industrial boiler is 36 mmBtu/hr, compared to 9.6 mmBtu/hr for the average commercial boiler.[71]

The biggest consumers of boiler fuel are the paper and chemicals industry, 2,200 TBtu/year and 1,800 TBtu/year, respectively. The chemicals industry consumes more than one third (775 TBtu/year) of the natural gas used in industrial boilers and the paper industry consumes 43 percent (1,406 TBtu/year) of the by-product fuel used in industrial boilers. Coal and coke are important fuels for the paper, chemicals, and primary metals industries. Other energy inputs, residual oil, distillate oil and liquefied petroleum gas (LPG) represent less than 5 percent of industrial boiler inputs.

Commercial boilers consume approximately 1,630 TBtu/year. Natural gas accounts for 83 percent of boiler fuel, coal at 8 percent, oil at 7 percent and other fuels at 2 percent.

Of the 8,100 trillion Btu consumed by the ICI boiler sector, industrial boilers burning by-product and waste fuels consume 3,249 Tbtu/yr according to the 2005 data cited above. The mercury emissions from these waste fuels would be unknown without extensive testing.

[71] Characterization of the U.S. Industrial/Commercial Boiler Population, Oak Ridge National Laboratory, May 2005

Large Industrial boilers burning coal and coke would have the greatest mercury emissions for the fuels used in the ICI boilers. As seen in the 2002 NEI inventory, ICI boilers burning coal have factor of 10 greater mercury emissions than ICI boilers burning wood or waste. Unlike the coal-fired electric utility sector, the ICI boilers firing oil emit an accountable amount of mercury.

5.2.1.b. Sector mercury emissions, nationally, and within Great Lakes

In 1997, the U.S. EPA's Mercury Study to Congress reported emissions of mercury from the Great Lakes States totaling 12.3 tons per year or 43 percent of the nationwide total for the ICI boiler sector. Data from the 2002 NEI for the Great Lakes States reports mercury emissions for coal and oil fired units at 2.59 tons per year. The Mercury Study used considerably higher emission factors, (16 to 18 pounds per trillion Btu), and assumed no control, and this could account for the large discrepancy between the NEI and the Study report to Congress.

Based upon ten source tests reported to the National Association for Clean Air Agencies (NAACA), coal fired units in this sector were found to be emitting mercury at the emission rate of 4.5 and 7.5 pounds per trillion Btu.[72]

Coal:

The following table, from the Energy Information Administration, identifies the larger coal users of the non-electric utility facilities in the Great Lakes States.[73]

[72] Reducing Hazardous Air Pollutants from Industrial Boilers Reducing Boilers: Model Permit Guidance, NAACA, June 2008
[73] Energy Information Administration, Department of Energy, Table 25, 2006
http://www.eia.doe.gov/cneaf/coal/page/acr/table25.html

Table H

Coal Consumers in the Manufacturing, 2006

Company Name	Top Ten Manufacturers	Plant Location
Great Lakes States		
Alcoa Inc (Aluminum Company of America)	Indiana	(IN)(TX)
Archer Daniels Midland	Indiana, Illinois	(IA)(IL)(MN)(ND)
Carmeuse North American Group	Indiana, Illinois, Ohio, Pennsylvania	(AL)(IL)(IN)(KY)(MI)(OH)(PA)
Dakota Gasification Company		(ND)
Eastman Chemical Company		(AR)(TN)
Georgia-Pacific Corp	Wisconsin	(AL)(GA)(OK)(VA)(WI)
Holcim (US) Inc		(AL)(CO)(IA)(MI)(MS)(SC)(UT)
International Paper Co	Indiana, Michigan, Minnesota, Wisconsin	(AL)(FL)(GA)(IN)(LA)(MI)(MN)(NC)(SC)(VA)(WI)
Lafarge North America	Illinois, Michigan, New York Pennsylvania	(AL)(IA)(IL)(KS)(MI)(MO)(NY)(OK)(PA)(SC)(WA)
NewPage Corporation	Ohio	(MD)(MI)(OH)(SC)(VA)
Other Major Manufacturers		
American Crystal Sugar Co	Minnesota	(MN)(ND)
Buzzi Unicem USA	Illinois, Indiana	(IL)(IN)(KS)(MO)(OK)(TX)
Cargill Incorporated	Michigan, New York, Ohio	(AL)(GA)(IA)(MI)(NC)(NY)(OH)(TN)
ESSROC Materials Inc	Indiana, Pennsylvania	(IN)(MD)(PA)
Eastman Kodak Company	New York	(NY)
International Steel Group Inc	Indiana	(IN)(MD)
Lehigh Cement Co	Pennsylvania	(AL)(IA)(IN)(MD)(PA)
MeadWestvaco	Michigan, Ohio	(MD)(MI)(OH)(SC)(VA)
Mittal Steel USA	Indiana	(IN)
Silver Bay Power Company	Minnesota	(MN)
Smurfit Stone Container Corp	Michigan	(FL)(MI)(SC)(VA)
Tate and Lyle Ingredients Americas Inc	Illinois, Indiana	(IL)(IN)(TN)
Weyerhaeuser Inc	Pennsylvania	(AL)(NC)(PA)(WA)
Zinc Corp of America	Pennsylvania	(PA)

Energy Information Administration publishes annual reports for nationwide coal use data for industrial sectors. For the ICI boilers, annual short tons of coal used per year were reported. Multiplying this data by the pound per trillion Btu developed by the National Association for Clean Air Agencies resulted in mercury emissions of 1.93 tons per year for 2006. The 2002 NEI data for ICI boilers firing coal was 1.92 tons per year.

Table I

(Thousand Short Tons)

State	2006 Electric Power	2006 Industrial	Trillion Btu per year Industrial	lbs of Mercury Per year
Illinois	53,939	3,608	93.808	703.56
Indiana	60,582	5,567	144.742	1085.57
New York	9,417	1,109	28.834	216.26
Ohio	58,604	1,931	50.206	376.55
Michigan	34,926	1,793	46.618	349.64
Minnesota	19,573	1,271	33.046	247.85
Pennsylvania	55,936	2,792	72.592	544.44
Wisconsin	23,702	1,758	45.708	342.81
Total				3866.66

[1] The electric power sector (electric utilities and independent power producers) comprises electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity
lbs of mercury based by an emission factor of 7.5 lbs Hg/Tbtu

Source: · Energy Information Administration

Oil:

The Energy Information Administration publishes annual reports for nationwide petroleum use, (distillate, kerosene and residual) and data for ICI sectors in 1000 gallons per year. The Factor Information Retrieval Data System (FIRE)[74] has an emission factor for only distillate oil at 3E-6 lbs of mercury per million Btu. Using above emission factor for all petroleum usage in the Great Lakes States obtained a yearly mercury emission value for petroleum of 1,065.4 lbs/yr. The 2002 NEI data for ICI boilers firing coal was 1,346.8 pounds per year.

According to the data presented in section a.), total Btu for the Industrial sector nationwide was estimated by Energy and Environmental Analysis Inc. at 6,470 Trillion Btu. With their estimation that 5 percent was attributed to oil usage, the industrial sector's total Btu should be 323.5 Tbtu. Based upon the Energy Information Association's state wide data, the Great Lakes States would represent 40 percent of that total. In the case of commercial boilers, the Energy and Environmental Analysis Inc. data states that commercial boilers would contribute 1,630 Tbtu and only 7 percent is contributed from oil. This equates to 114 TBtu nationwide, though the data below shows that the Great Lakes States contribute 225.61 TBtu, with the majority from New York. This discrepancy is large, but emissions from oil overall are a small contributor to nationwide mercury emissions.

Table J

2006

State	TBtu Industrial	TBtu Commercial	lbs of Mercury
Illinois	9.93	5.85	47.32
Indiana	20.00	8.43	85.30
Michigan	8.54	8.34	50.65
Minnesota	9.13	5.46	43.76
New York	18.94	142.01	482.85
Ohio	16.42	10.49	80.73
Pennsylvania	31.60	38.96	211.67
Wisconsin	14.95	6.07	63.08
Total	**129.51**	**225.61**	**1065.36**

5.2.1.c. Control Approaches

The Industrial, Commercial and Institutional sector utilizes various size boilers and fuels to fulfill the needs of the many source categories this sector covers. For solid fuel boilers, (i.e. coal and wood) with heat inputs of greater than 10 MMBtu/hr, the most effective control technologies identified by the U.S. EPA in the final rule of the NESHAP for Industrial/Commercial/Institutional Boilers for removing metallic compounds were fabric filters. About 14 percent of solid fuel-fired boilers use fabric filters. About 12 percent of solid fuel

[74] US EPA, Factor Information Retrieval Data System, Version 6.25

fired boilers use wet or dry scrubbers, and approximately 1 percent use packed bed scrubbers. Based on test information on utility boilers, fabric filters are determined to be the most effective technology for controlling mercury emissions.[75] The majority of solid fuel boilers would utilize electrostatic precipitators which have control efficiencies for mercury in the 30 percent range. Only 6 percent of liquid fuel boilers were identified with emission controls beyond basic particle devices.

Particle fabric filters tend to have the greatest effect of reducing mercury from solid fuel fired boilers due to the effect of unburned fuel (loss on ignition) resulting in carbon accumulating on the baghouse filter cake and adsorbing mercury. A study by the National Association of Clean Air Agencies (NACAA) found that the most efficient systems for controlling criteria and HAP pollutants such as PM, acid gases, mercury and metal HAPs were the use of an electrostatic precipitator (ESP) or wet ESP or a combination ESP/wet scrubber/WESP or wet scrubber/WESP. Based upon the facility's existing boiler configuration, either fabric filters or a combination of the above control devices recommended by NACCA would reduce mercury significantly.[76]

5.2.2 Existing and Prospective Federal Regulation

On September 13, 2004, the U.S. EPA promulgated the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Industrial/Commercial/Institutional Boilers and Process Heaters. The final rule included a health-based compliance alternative based upon threshold emission limits for hydrogen chloride and manganese. If an owner of a facility demonstrated that their boiler units could meet health based threshold emission limits, then EPA asserted that those units do not pose a significant risk to human health or the environment for these contaminants.

After promulgation of the final regulations for boilers and process heaters, the U.S. EPA received petitions for reconsideration of certain provisions in the final rule. On July 27, 2005, EPA published a notice of reconsideration and requested public comment on certain aspects of the health-based compliance alternatives. After evaluating public comment on the notice of reconsideration, U.S. EPA retained the health-based compliance alternatives in the final rule and made changes to simplify the process for demonstrating eligibility.

In July of 2007 the U.S. Court of Appeals (Natural Resources Defense Council v. EPA, No. 04-1385) vacated the NESHAP for Industrial/Commercial/Institutional Boilers and Process Heaters and partially vacated the Commercial and Industrial Solid Waste Incineration ("CISWI") Unit Rule. These two regulations had potentially overlapping requirements and the courts remanded the regulations back to the U.S. EPA for clarification.

The U.S. District Court for the District of Columbia has entered an order on consent, dated November 12, 2008 and revised on September 10, 2009, that in effect provides a deadline of April 2010 for EPA to propose MACT standards for Industrial/Commercial/Institutional (ICI) Boilers and section 129 standards for ***Commercial/Industrial Solid Waste Incinerators*** (CISWI) and a deadline of December 2010 for EPA to adopt emission standards assuring that source categories accounting for not less than ninety percent of the aggregate emissions of each of the hazardous air pollutants enumerated in section 112(c)(6) are subject to emission standards under section 112(d)(2 or (d)(4).

5.2.3 State and Federal Voluntary Programs Affecting Emissions from this Sector

[75] Revised MACT floor analysis. Docket No. OAR-2002-0058-0602, February 2004

[76] National Association of Clean Air Agencies, *Reducing Hazardous Air Pollutants from Industrial Boilers: Model Permit Guidance*, Washington, D.C. (June 2008).

The primary voluntary efforts affecting emissions from boilers relate to programs to promote fuel switching (i.e. from coal to natural gas or biomass), greater efficiency in energy production (for instance through combined heat and power), or greater efficiency in energy use. See section 5.1.1.c for a brief discussion of these issues.

5.2.4 Recommendations for State Action

- Recommendation 6: The U.S. EPA has entered into an order on consent to provide a proposed MACT standard for Industrial/Commercial/Institutional Boilers by April 2010, and in August 2008 issued an Information Collection Request (ICR). The Great Lakes States should supplement the information collected through the ICR by assembling stack testing information to assist in establishing a representative MACT standard for this source category and potential sub-categories Stack testing information should focus on varying fuel types, fuel load, boiler size and control equipment.
- Recommendation 7: When considering implementation of policies that promote energy efficiency and fuel switching, states should take into account the potential benefits that such policies will have for mercury emissions reduction, along with the other benefits and costs of such policies.

5.3 Mercury Cell Chlor-Alkali Industry

5.3.1 Background

Chlor-alkali plants produce chlorine and caustic soda (sodium hydroxide or potassium hydroxide) from brine. There are three basic types of chlor-alkali production technologies in use: mercury cells, diaphragm cells, and membrane cells. Only mercury cell plants use and release mercury; the other technologies are mercury-free. Mercury cell and diaphragm cell technology were first developed in the 19th century, while membrane cell technology first came into widespread use in the 1970s.

Mercury cells were built in the United States until 1971, but since then, all new mercury cell plants have been membrane cells, which have advantages over both mercury cells and diaphragm cells in energy and cost-efficiency, and over diaphragm cells in quality of caustic soda produced. There were 25 U.S. mercury cell plants in the 1970s, down to 14 by 1996.[77] By the end of 2008, there are expected to be only five mercury cell chlor-alkali plants still operating in the United States, producing less than 5 percent of the chlorine produced nation-wide.[78]

The number of mercury cell chlor-alkali plants has declined both due to plant closures resulting from shifting economic conditions and due to conversions of existing mercury cell plants to utilize membrane cell technology. In the Great Lakes states, there are two currently operating mercury cell chlor-alkali plants, one in Port Edwards, Wisconsin, the other in Ashtabula, Ohio. The Port Edwards facility, owned by ERCO Worldwide, has announced that it will convert to membrane cells; their goal is to convert by the end of 2009, leaving one remaining mercury cell plant in the Great Lakes states and four nationwide.

The chlor-alkali industry is a major user of mercury. Each mercury cell plant consists of 24 to 116 mercury cells, and each cell contains roughly three tons of mercury. While the mercury is recycled, mercury can be lost at various points in the process. As a result, chlorine and caustic soda production represented the largest use of mercury within the United States until the late 1990s, when mercury use began to decline as a result of industry shrinkage and efforts to improve mercury management. Because of their large inventories of elemental

[77] U.S. EPA, Mercury Report to Congress, Vol. 2, pp. 4-36 – 4-39.
[78] Simon Mahan and Jacqueline Savitz. *Cleaning Up: Taking Mercury-Free Chlorine Production to the Bank.* Oceana, July 2007.

mercury, when chlor-alkali plants close they become a significant source of mercury that must be disposed according to Federal requirements or sold in the U.S. commodity market.[79] See section 5.3.2, below.

Mercury cells utilize mercury as a flowing cathode in the separation of chlorine and sodium or potassium from brine. Mercury flows though an inlet inbox into an electrolyzer cell. A layer of purified sodium or potassium brine flows above the mercury. Titanium anodes suspended above the brine attract chlorine gas, while sodium or potassium forms an amalgam with the mercury cathode. The amalgam flows through an outlet end box and into a decomposer cell, in which the water and amalgam are separated into elemental mercury, sodium or potassium hydroxide and hydrogen gas. The mercury can then be recycled back into the cell.[80]

There are three main sources of air emissions from mercury cell chlor-alkali plants: the byproduct hydrogen stream, end box ventilation air, and cell room ventilation air. In addition, some chlor-alkali plants have thermal recovery units, in which mercury wastes from the chlor-alkali production process are retorted, providing mercury that can be returned to the process. These thermal recovery units are also a source of mercury emissions.

While mercury emissions from the byproduct hydrogen stream, the end box ventilation air, and the thermal recovery units are well-characterized, there is considerable uncertainty about emissions from the cell room. Unlike the hydrogen stream and end box ventilation air, the mercury cell room is a diffuse source. The mercury cell room is typically well-ventilated, with open sides and vents in the ceiling, to prevent excessive buildup of heat, mercury, or, in the case of an accident, chlorine gas. Mercury vapor enters the cell room and ultimately the outside air as the result of a variety of maintenance operations that can expose mercury to the air, as well as from mercury spills, and air leaks from mercury-containing equipment.

Under a 1987 emissions standard, mercury cell chlor-alkali plants were required to measure emissions from the hydrogen and end box ventilation streams, but not required to measure cell-room mercury emissions. Chlor-alkali plants that followed certain "housekeeping" practices to limit mercury releases were allowed by default to assume their cell room emissions were no more than 1.3 kg/day, or approximately 0.5 tons per year.[81] Given that these emissions were not measured, there was considerable uncertainty about whether this 1.3 kg per day estimate reflected reality. Moreover, an independent evaluation of the mass balance of mercury use at mercury cell chlor-alkali plants noted that chlor-alkali plants in the United States and Europe could not account for a significant percentage of the mercury purchased, raising the possibility that some of the missing mercury may be released to the air from the cell room.[82] In 2003, EPA reported from publically available data that the mercury releases reported to the air, water, and solid wastes in the 2000 Toxics Release Inventory (TRI) totaled around 14 tons. This left approximately 65 tons of consumed mercury that was not accounted for in the year 2000.[83]

In response to public concerns about this unaccounted mercury, the Chlorine Institute, which represents all U.S. mercury cell chlor-alkali manufacturers (as well as non-mercury chlorine manufacturers), began to report mass balance information for the U.S. mercury cells on an annual basis, beginning with data for 2002. They estimated their mercury inventory, mercury purchases, mercury use, reported toxics release inventory (TRI) emissions, mercury contained in chlor-alkali products, and any unaccounted mercury by difference from these values. The Chlorine Institute reported that the mercury cell plants had a total of 28 tons of unaccounted

[79] John L. Sznopek and Thomas G. Goonan. The Materials Flow of Mercury in the Economies of the United States and the World. U.S. Geological Survey Circular 1197, 2000.
[80] U.S. EPA, Mercury Report to Congress, Vol. 2, pp. 4-400.
[81] Mercury NESHAP, 40CFR 61, Subpart E.
[82] Robert Ayres. The Life-Cycle of Chlorine, Part I: Chlorine Production and the Chlorine-Mercury Connection. Journal of Industrial Ecology (January 1997). Vol. 1 Issue 1, pp 81 – 94.
[83] Preamble to 2003 Mercury Cell MACT (68 FR 70920)

mercury in 2002 and 30 tons in 2003. However, annual unaccounted for mercury was reduced to only six tons in 2004, three tons per year in 2005 and 2006, and four tons in 2007. The Institute credits better procedures for inventorying mercury contained within production equipment for this improvement.[84]

In addition, EPA studied fugitive mercury emissions from mercury cell rooms using data from an EPA source test program and continuous monitors operated by the facilities. EPA reported in 2008 that daily cell room mercury emissions range from approximately 20 g/day to 1,300 g/day, with an average of less than 500 g/day per facility (or around 0.2 tons per year). Thus, U.S. EPA concluded that cell-room mercury emissions are, on average, actually well below 1.3 kg/day.[85]

5.3.1.a. Control Approaches

The hydrogen stream and the end box ventilation air are point source emissions that can be routed to an emissions control device. Mercury emissions from both these sources can be minimized by cooling the gas stream, passing it through a mist eliminator, and finishing it with control devices such as carbon adsorbers. The thermal recovery unit is also a point source that can be controlled by devices such as carbon adsorbers.

Given the configuration of mercury cell rooms, cell-room emissions cannot be controlled through a single emissions control device. However, the diffuse mercury emissions from the cell room can be minimized by the use of equipment that helps minimize the need for intrusive maintenance, and by a variety of other "housekeeping" practices that minimize exposure of mercury to air.[86]

In addition to control approaches that reduce the mercury emissions from existing mercury cell chlor-alkali plants, mercury emissions can be eliminated by converting mercury cell plants to the mercury-free membrane cell technology. In many cases, chlor-alkali plant owners have found it advantageous to convert to membrane cell technology in order to take advantage of lower operating costs despite the high capital costs of the conversion. Erco Worldwide decided to invest over $95 million (with the current estimate now over $130 million) to convert the mercury cells in Port Edwards, Wisconsin to membrane cells, after calculating that the conversion would increase power efficiency by 30 percent, reduce annual fixed costs due to mercury use and environmental compliance, and avoid needed capital investments in upgrading the mercury cell technology.[87] Whether such investments are economically attractive depends on numerous factors, including the age and condition of the mercury cell equipment and the cost of electricity, with higher electricity costs making an energy-saving conversion more attractive. However, Erco's original plan to begin to convert before the 2003 MACT compliance date of 2006 was halted because of a failed price negotiation with the local power company. Obviously, the economic conditions favorable to a conversion to non-mercury technology are complex.

5.3.2 Existing and Prospective Federal Regulation

U.S. EPA issued a Maximum Available Control Technology (MACT) standard to minimize mercury emissions from mercury-cell chlor-alkali plants in 2003. This standard prohibits the use of mercury cell

[84] Chlorine Institute, Eleventh Annual Report to EPA: Chlor-Alkali Industry Mercury Use And Emissions in the United States for the Year 2007. September 26, 2008. The primary uncertainty in this calculation is the amount of mercury in inventory within the chlor-alkali plant equipment. Chlor-alkali plants measure mercury process inventory using a radioactive isotope technique which has a variability of between 0.1 and 0.3 percent. Applying this variability to the 2006 year ending mercury inventory of 2,102 tons reveals the data to be accurate to within two to six tons.

[85] U.S. EPA, FACT SHEET: Proposed Amendments to Air Toxics Standard: Mercury Emissions from Mercury Cell Chlor-Alkali Plants, June 2008.

[86] Guidelines for Mercury Cell Chlor-Alkali Plants Emission Control: Practices and Techniques; The Chlorine Institute: Washington, DC, April 2001.

[87] Erco Worldwide. Port Edwards Membrane Conversion Evaluation. Great Lakes Bi-National Toxics Strategy Mercury Workgroup. December 6, 2006, and Chemweek's Business Daily. Erco to Convert Port Edwards Chlor-Alkali from Mercury. August 10, 2007.

technology in new chlor-alkali plants. It also sets mercury emissions limits for by-product hydrogen streams, end box ventilation systems, and mercury recovery facilities at chlor-alkali plants. The standards for by-product hydrogen streams and end box ventilation systems are expressed in grams of mercury emitted per metric ton of chlorine produced, while the standard for mercury recovery facilities is expressed in milligrams of mercury per dry standard cubic meter of exhaust gas. These standards effectively reduce allowable mercury emissions from hydrogen streams and end box ventilation systems to 60 grams per day, down from 1000 grams per day in the previous (1973) air emissions regulation. In 2008, EPA determined that mercury emissions from these point sources declined 88 percent from pre-2003 levels, including both the impacts of emissions controls and plant shutdowns. The MACT standard also required rigorous work practice standards, including:

- Either end boxes must be equipped with fixed covers or that end box headspaces must be routed to a ventilation system;
- Pipes for transporting liquid mercury must have smooth interiors;
- Cell room must floors be free of cracks and chips, and must be coated with a material resistant to mercury absorption;
- Containers used to store liquid mercury must have tight-fitting lids;
- Electrolyzers and decomposers must be cooled before opening;
- Liquid mercury in end boxes and mercury pumps must be covered by an aqueous liquid at a temperature below its boiling point at all times;
- End box access port stoppers must be maintained in good sealing condition;
- All parts removed from the decomposer for maintenance must be rinsed prior to transport to another work area.

Moreover, twice-daily inspections are required to ensure that equipment is operating properly and that spills are identified and cleaned up within an hour of being identified. U.S. EPA was not able to accurately quantify the reductions associated with these work practice standards, though it is believed that they are reducing mercury air emissions. This original 2003 MACT standard established a cell room monitoring option to address mercury emissions as an alternative to the work practice program.

In February 2004, the Natural Resources Defense Council (NRDC) and other interested parties filed petitions for reconsideration of the MACT, specifically relating to uncertainty in fugitive mercury air emissions. U.S. EPA agreed to reconsider the rule as a result of the NRDC petition. As part of the rule reconsideration, U.S. EPA performed a test study in 2006 to measure fugitive mercury air emissions from the cell rooms of two facilities and obtained measurement data from two other facilities. The U.S. EPA study found that cell room mercury emissions averaged less than 500 grams/day. In 2008, U.S. EPA proposed several revisions to the MACT standard. Most notably, U.S. EPA has proposed making it mandatory that mercury cell chlor-alkali plants employ mercury monitoring system as a work practice tool to reduce fugitive emissions in the cell room in addition to requiring work practices to reduce mercury emissions. U.S. EPA expects to finalize amendments to the MACT standard in 2009.[88]

In addition to the regulation of air emissions from chlor-alkali plants, the Federal government has imposed restrictions on the export of mercury that will impact chlor-alkali plants that close or convert to membrane technology, freeing up mercury for sale. The Toxic Substances Control Act, as revised by the Mercury Export Ban Act of 2008, prohibits commercial export of mercury from the United States starting in 2013. Moreover, the Mercury Export Ban Act requires the Department of Energy to designate a facility for long-term mercury storage and to accept unwanted elemental mercury from the public at that facility, for a fee that reflects "the pro rata cost of long-term management and storage of elemental mercury delivered to the facility." Therefore, starting in 2013, when a chlor-alkali facility closes, the mercury freed up cannot be sold to overseas markets.

[88] Proposed Revisions to National Emission Standards for Hazardous Air Pollutants: Mercury Emissions from Mercury Cell Chlor-Alkali Plants, 73 FR 33257.

Chlor-alkali companies will be able either to sell the mercury for domestic use, or pay a fee to have the Department of Energy store it.[89]

5.3.3 Existing and Prospective State Regulation

There are currently no state regulations affecting this sector in the Great Lakes.

5.3.4 State and Federal Voluntary Programs Affecting Emissions from this Sector

In 1996, the Chlorine Institute committed, under the Great Lakes Binational Toxics Strategy, to voluntarily reduce mercury use and emissions, with a specific goal of 50 percent reduction in mercury use by 2005. The 50 percent reduction commitment is calculated on a capacity-adjusted basis, so as not to reflect reductions resulting from plant closures or conversions, using as a baseline the average annual use between 1990 and 1995. Under this voluntary program, the Chlorine Institute has submitted eleven annual reports to U.S. EPA describing the industry's mercury reduction activities and reporting on the industry's mercury use. Under this program, the industry has performed a number of activities to promote mercury reduction, including development of guidance on disposal of mercury-contaminated cell parts, conducting mercury balances, reducing the mercury content of sodium hydroxide (caustic soda), and reducing cell-room emissions. As described above, the Chlorine Institute has also developed an industry-wide mercury balance that significantly reduced the amount of unaccounted mercury.

The voluntary program has proven successful in reducing mercury use, far exceeding the original goal of 50 percent reduction. Mercury use declined 91 percent on a capacity-adjusted basis between 1995 and 2005 with a decline of 94 percent when plant shutdowns and conversions are included. While it is likely that reduced air emissions are at least partially responsible for the reduction in mercury use, in the absence of routine cell-room emissions quantification it is impossible to determine the extent to which the reduction in mercury use stems from reduced losses of mercury to the atmosphere, as opposed to other potential factors such as reduced mercury content of wastes and improved accounting of mercury inventory.

5.3.5 Recommendations for State Action

- Recommendation 8: States should encourage responsible management of surplus commodity grade mercury when a chlor-alkali plant converts to a mercury-free process or closes. Responsible management would including meeting all regulatory requirements related to mercury removal and contracting with experienced and reputable firms.
- Recommendation 9: States should consider offering incentives to expedite the transition to mercury-free chlor-alkali production. Possible incentives could include expediting regulatory approvals, altering compliance deadlines, and state support for stable, long-term electrical rates to add predictability to input costs.

5.4 Metals Production

5.4.1 Background

Metals production leads to mercury emissions for two different reasons: the presence of mercury-containing devices in metal scrap used in secondary metals production and the use of raw materials that contain trace levels of mercury in primary metals production. Mercury-containing devices are found in autos, appliances, and a variety of industrial equipment that gets recycled at the end of its life. If the mercury-containing devices are not removed, mercury will be emitted when the scrap is melted. Primary metals production also leads to mercury emissions, because many of the raw materials used, including metal ores and coal, contain mercury that is released during the production process**.**

[89] 110th Congress of the United States, Second Session, S. 906.

The largest metal production sources of mercury emissions within the Great Lakes states are thought to be:

Emissions related to mercury-containing devices in scrap

- Electric arc furnaces
- Iron and steel foundries
- Basic oxygen furnaces at integrated Steel Mills
- Production of zinc and other non-ferrous metals from recovered steel furnace flue dust

Emissions related to mercury naturally in raw materials

- Taconite production
- Ferroalloys production
- Coke production at integrated steel mills

In some cases, mercury emissions from a single source will occur as a result of both mercury devices in scrap and raw materials. For instance, a small percentage of mercury emissions from electric arc furnaces occur as the result of inputs of coal or direct reduced iron, although most of the emissions result from the use of steel scrap. Emissions at integrated steel mills are related to use of steel scrap and coking coal, as well as other inputs to the furnaces such as coal, limestone, and iron ore. These other inputs are not thought to result in large mercury emissions.

5.4.2 Electric Arc Furnaces, Iron and Steel Foundries, Basic Oxygen Furnaces and Scrap Melting

Mercury switches, measurement and control devices are contained in iron and steel equipment, notably automobiles, commercial appliances, and a wide array of industrial equipment. Scrapped equipment is often shredded, causing breakage of some of these mercury-containing devices and consequently, mercury emissions from the shredder. Shredded and crushed equipment is then fed into a steelmaking furnace, leading to emissions of most of the mercury input, since emissions control devices commonly in use at steelmaking furnaces are not effective at capturing mercury. Electric arc furnaces (EAFs) use virtually 100 percent steel scrap, while basic oxygen furnaces in use at integrated steel mills can use up to 30 percent steel scrap to produce new steel.[90] Moreover, EAFs typically use post-consumer scrap such as scrapped vehicles and other appliances and machinery, while integrated steel mills are more likely to use scrap generated during the production of steel and during production of steel products, but not the products themselves. U.S. EPA estimates that in 2002, 10.7 tons of mercury was emitted from electric arc furnaces. The EAF sector is the second-largest source of mercury emissions in the United States after power plants (coal-fired utility boilers).[91] An additional 1.75 tons were emitted from iron and steel foundries, which use melted scrap to produce metal casts for numerous products. Nearly all of the mercury emissions from EAFs and iron and steel foundries come from mercury-containing devices within the scrap.

The Great Lakes states include significant steel production capacity, accounting for an estimated 56 percent of raw steel produced in the United States.[92] Six of the Great Lakes states -- New York, Pennsylvania, Ohio, Indiana, Illinois, and Michigan -- account for 47 percent of the EAFs and 40 percent of EAF production capacity in the United States.[93]

5.4.2.a. Control Approaches

Mercury emissions from steel production facilities can be reduced by removing mercury-containing devices from equipment before it is scrapped. In particular, removal of vehicle switches from automobiles

[90] http://www.steel.org/Content/NavigationMenu/LearningCenter/SteelGlossary/Steel_Glossary.htm

[91] According to U.S. EPA's National Toxics Inventory. See http://www.epa.gov/region5/mercury/progress06.pdf

[92] Communication from Robert MacDonald, Director of Statistics, American Iron and Steel Institute, September 23, 2008.

[93] Ecology Center, Great Lakes United, University of Tennessee Center for Clean Products and Clean Technologies. Toxics in Vehicles: Mercury. January 2001.

addresses one of the most important sources of mercury inputs into steel production. EPA estimates that removal of 80 percent of mercury-containing vehicle switches from scrap inputs to steel furnaces would reduce mercury emissions by approximately half. In addition, emissions can be reduced by removal of mercury from appliances that are recycled under municipal and industry-sponsored white goods recycling programs, or by removal of mercury devices from industrial equipment and construction and demolition waste.

There is also some evidence that particulate emissions control devices, such as fabric filters, in use at steel production facilities can reduce mercury emissions. However, the control effectiveness of these devices for mercury removal is thought to be poor at steel plants. Moreover, the control residues from control devices used by electric arc furnaces are typically sent to secondary non-ferrous smelters because of their high zinc content; therefore, increased mercury capture at a steel furnace may lead to corresponding increases in mercury emissions at secondary non-ferrous smelters (see section 5.4.3).

U.S. EPA has evaluated potential use of mercury-specific control technology at electric arc furnaces. This evaluation found that: "activated carbon injection has been used on other somewhat similar processes (i.e., similar with respect to temperature and volumetric flow rate); however, it has never been used at EAF facilities, and thus is not a demonstrated mercury control technology for EAF facilities." U.S. EPA estimated that use of activated carbon injection could reduce mercury emissions from electric arc furnaces by 90 percent at a cost of $22 million per ton removed, in addition to increased waste treatment and disposal costs that would be incurred as a result of landfilling the mercury-contaminated treatment device residues. If the residues were recycled in a smelter, as is typically the case, the mercury would be released to the atmosphere.[94]

5.4.2.b. Existing and Prospective Federal Regulation

U.S. EPA regulates mercury emissions from electric arc furnaces (EAFs) and iron and steel foundries by requiring that these facilities utilize auto scrap only if the mercury switches have been removed first. The first category of these facilities to be regulated was major source iron and steel foundries, regulated under a 2004 MACT standard. Major sources emit more than 10 tons per year of a single hazardous air pollutant (HAP), or more than 25 tons per year of all HAPs combined. Rules were published in the Federal Register for "area source" iron and steel foundries (those not meeting the major source threshold) on January 2, 2008, and for area source electric arc furnaces on December 28, 2007. U.S. EPA plans to develop regulations for major source electric arc furnaces and for integrated steel mills that utilize post-consumer scrap, incorporating scrap management requirements similar to those contained in the area source standards. In addition, U.S. EPA plans to update the major source iron and steel foundry standards to make them consistent with the newer area source standards.[95]

The control standard for area source EAFs and iron and steel foundries provides four options for the subject steelmaking facilities to utilize in dealing with each supplier, contract, or shipment of scrap:

"1. Prepare, submit for approval, and implement a detailed site-specific plan for the removal of mercury switches from motor vehicle scrap;

2. Certify that you participate in and purchase motor vehicle scrap only from scrap providers who participate in an EPA-approved program for the removal of mercury switches;

3. Certify that the only materials from motor vehicles in the scrap are those recovered for their specialty alloy content and that the scrap is not reasonably expected to contain mercury switches; or

[94] National Emission Standards for Hazardous Air Pollutants for Area Sources: Electric Arc Furnace Steelmaking Facilities; Proposed Rule, 72 FR 53825, September 20, 2007.

[95] Conversation with Phil Mulrine, Office of Air Quality Planning and Standards, October 16, 2008.

4. Certify that the scrap does not contain motor vehicle scrap."[96]

At any given EAF, some scrap suppliers, contracts or shipments may be subject to one compliance option, while others are subject to other compliance options.

Under the first compliance option, the steel-making facility must obtain the permitting authority's approval for a site-specific compliance plan that contains provisions to obtain assurance from scrap providers that mercury switches have been removed. The plan must include: a means of communicating the need for mercury switch removal to the scrap supplier; a means of obtaining assurance from the supplier that switches have been removed and properly managed, and provisions for periodic inspections or other mechanisms to assure that switches are being removed. The facility must also establish a goal of at least 80 percent removal of mercury switches for each supplier, and must submit semiannual progress reports for each supplier, including an estimate of the number percentage of switches removed and a certification that mercury switches were properly recycled under subtitle C of the Resource Conservation and Recovery Act (RCRA). A steelmaking facility that utilizes a site-specific compliance plan must submit the plan for approval by the permitting authority; if the plan is disapproved, the facility must correct any deficiencies within 60 days.

Under the second option, EPA-approved programs include the National Vehicle Mercury Switch Recovery Program (NVMSRP) and a Vehicle Switch Recovery Program mandated by Maine State law (ME-VSRP). Other programs may also be considered but have to abide by specific guidelines, which include:

- Outreach informing dismantlers of the need for mercury switch removal as well as training/guidance for removing switches.
- Scrap providers must aim to remove at least 80 percent of all switches from the motor vehicle scrap.
- Progress reports must be submitted to the U.S. EPA Administrator at least annually and include:
    - Number of switches removed or weight of mercury recovered;
    - An estimate of the number of vehicles processed;
    - Approximation of the percent of mercury switches recovered; and
    - Certification that the facilities where the recovered switches were recycled have the required permits under subtitle C of RCRA.[97]

The mercury control requirements for major source iron and steel foundries have many similarities to the requirements for area source EAFs and iron and steel foundries. Foundries can comply either by using only scrap that is certified not to include any post-consumer auto scrap or by adopting a scrap selection plan. Under the scrap selection plan, foundries must certify that their scrap suppliers have implemented procedures to remove mercury switches from automotive scrap, and must adopt visual inspection procedures to ensure that scrap meets specifications. However, the major source foundry provisions differ in some important ways from the area source rules. Most importantly, since the major source iron and steel foundry rule was finalized in 2004, prior to the creation of the NVMSRP, there is not a compliance option that refers specifically allows for obtaining scrap only from suppliers that participate in an EPA-approved switch removal program.[98] U.S. EPA plans to update these standards, making the scrap management provisions consistent with the area source standards.

5.4.2.c. Existing and Prospective State Regulation

[96] U.S. EPA, Office of Air Quality Planning & Standards, Summary of Regulations Controlling Air Emissions from Electric Arc Furnace (EAF) Steelmaking Facilities, April 2008; and U.S. EPA, Office of Air Quality Planning & Standards, Summary of Regulations Controlling Air Emissions from Iron and Steel Foundries Area Sources, April 2008.
[97] Quicksilver Caucus "Electric Arc Furnace Area Source Rule Mercury Requirements Factsheet for States and Local Agencies"
[98] American Foundry Society, Inc. *Iron & Steel Area Source Standards* http://www.afsinc.org/content/view/101

New Jersey regulations limit mercury emissions from "iron or steel melters," a category that includes electric arc furnaces and cupolas, including those located at iron and steel foundries. Department of Environmental Protection (NJDEP) set forth strict regulations to address the release of emissions from melting mercury-containing scrap metal. Effective January 3, 2010, iron and steel melters must either meet an emissions standard of no more than 35.0 mg mercury per ton of steel produced, or an emissions control standard of 75 percent reduction. These criteria are "based on the annual weighted average of all valid stack emission tests performed for four consecutive quarters weighted for the production each quarter."[99] In addition, iron and steel melters were required, beginning in 2006, to submit plans to the New Jersey Department of Environmental Protection for reducing mercury in scrap. These plans must include a 'materials acquisition program' with the goal of ensuring that scrap is purchased only from suppliers that either remove all accessible mercury switches or supply scrap that is already mercury-free, and visual inspection procedures to verify that a representative sample (at least 10 percent) of both incoming mercury-free scrap and incoming mercury-removed scrap meet the requirements.

In addition, some states place requirements in air permits for auto shredders, requiring them to assure that mercury-containing devices have been removed from autos prior to shredding. In some cases, the permits also require mercury emissions testing. Michigan air permits require all new shredders to have material management plans, which include mercury switch management. New York requires mercury switch removal in auto shredder stormwater permits, and Wisconsin has included mercury switch removal requirements in stormwater permits for auto recyclers.

5.4.2.d. State and Federal Voluntary Programs Affecting Emissions from this Sector

The National Vehicle Mercury Switch Recovery Program (NVMSRP) was established by an August 2006 agreement among U.S. vehicle manufacturers, steelmakers, vehicle dismantlers, auto shredders, brokers, the environmental community, state representatives and U.S. EPA. Under this nationwide program, vehicle manufacturers must provide auto dismantlers with information and supplies for mercury switch removal, collect and transport switches to handlers for proper recycling or disposal, assume liability for the switches once collected, establish a database to track switch recovery by program participants, and disburse incentive payments to eligible participants. The program's goal is to achieve, in conjunction with existing state programs, an overall 80-90 percent rate of mercury switch recovery. To carry out these responsibilities, automakers have voluntarily formed the non-profit organization End of Life Vehicle Solutions (ELVS). As of 2008, ELVS has fifteen members including BMW, Daimler EAPP, Chrysler, Ford, General Motors, International Truck, Mack Truck, Mitsubishi, Nissan, PACCAR, Porsche, Subaru, Toyota, Volkswagen, and Volvo Trucks.[100] The NVMSRP has also set aside a $4 million fund to encourage dismantlers and recyclers to remove mercury switches by paying incentive fees for each switch removed during the first three years of the program. The fee has been set at $4 for switches removed from convenience lighting and $6 for switches removed from anti-lock braking systems.

With the exception of Indiana, all of the Great Lakes states participate in the NVMSRP, therefore making the incentive fees available to participating dismantlers and recyclers. Indiana has a mandatory program that requires the removal of all mercury switches. As an incentive, Indiana pays motor vehicle recyclers $3 for each mercury switch and $5 for each ABS sensor or other component containing more than 10 mg of mercury that is removed and properly recycled. While Indiana does not participate directly in the NVMSRP, Indiana's motor vehicle recyclers use the ELVS mercury switch collection and accounting system established under the

[99] Chapter 27 Air Pollution Control, subchapter 27 Control and Prohibition of mercury emissions, section 7:27-27.6 Iron or steel melters http://www.state.nj.us/dep/aqm/Sub27.pdf

[100] ELV Solutions Homepage. See http://www.elvsolutions.org/. See also http://www.epa.gov/mercury/switch.htm.

NVMSRP. For additional information on efforts to reduce inputs of mercury in metal scrap, see section 6.2 of the *Mercury in Products Phase-Down Strategy*.

Illinois has a mandatory vehicle mercury switch removal program, which has similar elements to the voluntary National Vehicle Mercury Switch Removal Program. The Illinois program requires that auto dismantlers and recyclers achieve minimum capture rates for convenience light switches, with 50 percent captured between July 2007 and June 2008, and 70 percent captured between July 2008 and June 2009 and subsequent years. If these capture rates are not met, affected auto manufacturers are required to pay dismantlers and recyclers $2 for each mercury switch removed, and to reimburse them for the costs of collection containers and packaging and transport of the mercury switches. Illinois EPA has already notified auto manufacturers that the 50 percent capture target was not met for July 2007 through June 2008, thereby triggering the obligation to provide the specified reimbursements, effective September 1, 2008. Illinois EPA will review the $2 incentive fee every three years to determine whether it "should be modified to ensure adequate compensation for the removal of mercury switches from end-of-life vehicles." In addition, failure to meet the capture target triggered a requirement on auto recyclers, vehicle crushers and scrap metal recyclers in the state to remove mercury switches from scrap vehicles before they are flattened, crushed or baled for processing as scrap metal.[101]

In addition, many municipalities include mercury switch removal in their recycling programs for "White Goods," or large appliances. See section 6.2.2.7 of the *Mercury in Products Phase-Down Strategy*.

5.4.2.e. Recommendations for State Action

- Recommendation 10: States should implement the recommendations of the *Mercury in Products Phase-Down Strategy* related to phasing out use of mercury devices and to promoting the removal of mercury switches from end-of-life vehicles and appliances.
- Recommendation 11: States should include permit conditions requiring proper management of scrap that is likely to contain mercury switches at metal shredders, contingent on obtaining such authority in states where it is lacking (see recommendation 26).

5.4.3 Secondary Non-Ferrous Metals Production

While steel furnaces do not typically have emissions control equipment specifically designed to capture mercury, particulate control devices at these facilities capture a small percentage of mercury. Steel furnace flue dust from particulate control devices is typically sent to secondary non-ferrous metals production facilities, because of the high zinc content of this dust. This process, however, uses high heat that may volatilize mercury contained in the dust.[102] EPA's 2006 Toxics Release Inventory contains mercury emissions reports from four facilities in the Great Lakes states that process electric arc furnace flue dust:

- Inmetco International Metals, in Ellwood City, Pennsylvania, which reported 384 pounds of mercury emissions;
- Horsehead Resource Development in Palmerton, Pennsylvania, which reported 220 pounds of mercury emissions;
- Horsehead Resource Development in Chicago, Illinois, which reported 182 pounds of mercury emissions;
- Horsehead Resource Development in Monaca, Pennsylvania, which reported 27 pounds of mercury emissions.

[101] Illinois Public Act 094-0732 and Douglas P. Scott, Director, Illinois EPA, Letter to Mary Bills, Executive Director, End of Life Vehicle Solutions, July 28, 2008.

[102] U.S. EPA, Compliance Assistance and Sector Programs Division, Profile of the Iron and Steel Industry (EPA/310-R-95-005), September 1995.

5.4.3.a. Control Approaches

We are not aware of any efforts to evaluate mercury control approaches at secondary non-ferrous metals production facilities. General efforts to limit mercury contamination of scrap will ultimately reduce mercury emissions from secondary zinc smelters (see section 5.4.2 above, and section 6.2 of the *Mercury in Products Phase-Down Strategy*).

5.4.3.b. Voluntary Programs and Regulations

There are currently no voluntary programs at the federal or state level specifically targeted at reducing mercury emissions from secondary non-ferrous metals production facilities. EPA has promulgated standards for area source secondary non-ferrous metals processing (brass, bronze, magnesium and zinc), but these do not include any mercury emissions standards. Moreover, some mercury-emitting non-ferrous metals production facilities may not be subject to any national emissions standards because they do not fit the definition of an applicable source for any particular regulation. The same may be true of some primary metals production sources. Therefore, U.S. EPA is undertaking a project to evaluate non-ferrous metals production facilities, determine which ones are subject to emissions control standards, and identify potential needs for additional standards.

5.4.3.c. Recommendations for State Action

- Recommendation 12: The Great Lakes states should work with U.S. EPA to identify non-ferrous metals production facilities and determine whether they are subject to emissions control standards for hazardous air pollutants.

5.4.4 Taconite Production

Taconite is a low grade iron ore processed through crushing, magnetic separation and superheating. Atmospheric mercury releases occur primarily during the processing of "green balls" of ore into taconite pellets, a process that involves heating in an induration kiln at 1200 – 1300^{o}C. It is during these stages in the production of taconite pellets processing that naturally occurring elemental mercury within the ore is volatized. Taconite production takes place at six facilities in Minnesota's Iron Range and at two facilities in Michigan's Upper Peninsula. In 2005, the Minnesota Pollution Control Agency determined that taconite processing is the second largest mercury emissions source within the state, comprising an estimated 20 percent of total emissions;[103] taconite accounts for only 1 percent of Michigan's mercury emissions inventory.[104]

5.4.4.a. Control Approaches

Existing emissions control devices capture a small percentage of mercury at taconite production facilities. Most taconite furnaces use wet scrubbers, which are effective at capturing oxidized mercury (Hg^{2+}) but not elemental mercury (Hg0). Tests indicate that scrubbers capture 10 to 40 percent of mercury at taconite furnaces, likely indicating a range in the share of mercury in the oxidized form.[105]

[103] http://www.mepartnership.org/documents/MFM%20campaign%20sheet_ak_taconite_2004.12.14_final.pdf
[104] Michigan Department of Environmental Quality, *Mercury Strategy Staff Report*, January 3, 2008 (Updated August 1, 2008).
[105] Dennis L. Laudal and Grant E. Dunham, *Mercury Control Technologies For The Taconite Industry*. Prepared for Minnesota Department of Natural Resources, Division of Lands and Minerals. Energy and Environmental Research Center, University of North Dakota. June 2007.

A report conducted for the Minnesota Department of Natural Resources evaluated potential approaches for improving mercury control at taconite facilities. Promising approaches include:

- Injection of mercury sorbents into the gas stream, possibly with installation of a baghouse either in addition to or in place of the scrubber, in order to improve capture.
- Use of fixed bed sorbent reactors to oxidize a higher percentage of the mercury, thereby improving capture efficiency of the existing scrubbers.
- Use of chemical oxidants to the gas stream, such as chloride and bromide salts or hydrogen peroxide.
- Use of halogenated oxidants in conjunction with activated carbon injection.

Development of technologies to improve mercury capture is in the very early developmental stage. The report concludes that additional testing and development of these technologies is needed before any of them can be utilized on a broad scale within the taconite industry.[106]

Implementation of control technology research will be overseen by a "mercury emissions reduction research and implementation council," with "possible representation from the taconite industry, academia, MDNR, MPCA, electric utilities, and technical research entities."

5.4.4.b. Voluntary Programs

Under the Strategy Framework for Implementation of Minnesota's Statewide Mercury MACT (see section 6.3), the taconite industry within Minnesota has agreed to reduce mercury emissions collectively from 735 pounds in 2005 to 210 pounds by 2025, a 71 percent reduction. The industry has not yet identified the precise technologies that will be used to achieve this reduction, but it has agreed to the following interim goals to develop the needed technology:

- "Complete medium and longer-term testing of identified mercury-reduction control technologies on at least one straight-grate furnace and one grate-kiln furnace by 2013.
- Begin the first full-scale installation of mercury emission control equipment on one existing furnace in 2014.
- Based on results of full-scale installation and optimization, provide schedule for implementation at all other existing furnaces by 2016." The 2016 implementation schedule would ensure that reductions would occur at all facilities no later than 2025.

5.4.4.c. Regulations

U.S. EPA promulgated a MACT standard for taconite facilities in 2003. This standard does not include any mercury emissions standards, but sets particulate matter control standards as a surrogate for air toxics emissions, including manganese, chromium, cobalt, arsenic, and lead. While particulate controls do not achieve large reductions in mercury emissions, they do achieve some reductions. U.S. EPA estimated that of the eight existing taconite production plants, four facilities (containing six indurating furnaces) would need to upgrade particulate control equipment as a result of the MACT standard. [107] U.S. EPA evaluated the potential for setting a mercury standard, and determined that "There is no way to set a floor standard for mercury that is 'achievable,' as required by CAA section 112(d)(2), because there is no standard that can be duplicated by different sources or [that is] replicable by the same source."[108]

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[106] Dennis L. Laudal and Grant E. Dunham, *Mercury Control Technologies For The Taconite Industry*. Prepared for Minnesota Department of Natural Resources, Division of Lands and Minerals. Energy and Environmental Research Center, University of North Dakota. June 2007.

[107] Katherine Heller, Brooks M. Depro, Jui-Chen Yang, Laurel Clayton. Taconite Iron Ore NESHAP Economic Impact Analysis. Prepared for U.S. EPA, Office of Air Quality Planning and Standards. August 2003. EPA-452/R-03-015.

[108] 68 FR 61879

5.4.4.d. Recommendations for State Action

- Recommendation 13: States that have taconite production plants should promote participation by these plants in the voluntary mercury reduction activities outlined in the Strategy Framework for Implementation of Minnesota's Statewide Mercury TMDL Implementation Plan, which strive to reduce emissions by 75% by 2025.

5.4.5 Ferroalloys Production

Ferroalloys production includes electrometallurgical operations that produce silicon metal, ferrosilicon, ferrotitantium, ferrovanadium, ferromolybdenum, calcium carbide, ferromanganese, silicomanganese, ferrochromium, ferronickel, etc. When the Ferroalloys NESHAP was promulgated in 1999, there was only one major source producing ferromanganese and silicomanganese. Like taconite, manganese ore contains trace levels of mercury. There is one major user of manganese ore for ferroalloys production in the Great Lakes states—Eramet Marietta in Marietta Ohio. Eramet uses manganese ore in the production of ferromanganese and silicomanganese, and also has the ability to produce ferrochromium. In addition to manganese ore, the facility utilizes ferrous and nonferrous oxides, coke, coal, wood, and limestone in furnaces that heat the material to 3000^{o}F. According to the Toxics Release Inventory, this facility had emitted an estimated 373 pounds of mercury in 2006 and 427 pounds in 2005.

5.4.5.a. Control Approaches

Particulate emissions control devices, such as scrubbers and fabric filters, achieve some mercury control at ferroalloy production facilities, but still allow significant mercury releases. Mercury-specific control technologies are available, but are not in use at U.S. ferroalloys facilities. Norwegian ferroalloys production facilities utilize an emissions control system in which a mercury adsorber is added after a wet scrubber and a wet electrostatic precipitator, collectively achieving greater than 99 percent mercury removal. For one of these facilities, the controls were added in 2001 and 2002, coinciding with a decision to switch from low mercury manganese ores from Australia and South Africa to a high-manganese ore from Gabon. This switch would have resulted in an increase in mercury emissions from 10 kg/year to between 600 and 1000 kg/year.[109]

5.4.5.b. Voluntary Programs

We are not aware of any beyond-compliance efforts to control mercury emissions from the Eramet-Marietta facility.

5.4.5.c. Regulations

The Eramet Marietta facility is regulated under the 1999 Ferroalloys Production MACT standard, which sets emissions limits for particulate matter and opacity limits as a proxy for metallic hazardous air pollutants. Separate standards apply to two different types of electric furnaces, to the metal oxygen refining process, and to crushing and screening operations. The standard also includes work practices requirements to limit the release of fugitive dust. This standard does not include any mercury-specific requirements.[110]

[109] Tor Faerden, Norwegian Pollution Control Authority. Reduction of Mercury Emissions from Manganese Industry and Secondary Steel Industry. Convention on Long-range Transboundary Air Pollution Task Force on Heavy Metals, Fourth Meeting, 6 - 8 June 2007, Vienna (Austria). Downloaded on December 11, 2008 from http://www.unece.org/env/lrtap/TaskForce/tfhm/4thmeeting.htm.
[110] 40 CFR Part 63 Subpart XXX—National Emission Standards for Hazardous Air Pollutants for Ferroalloys Production: Ferromanganese and Silicomanganese

The Norwegian Pollution Control Authority has issued permits for four ferromanganese production facilities which contain mercury emissions limits set based on national emissions reduction goals, best available technology, and plant-specific conditions. These emissions limits range from 10 kg to 36 kg per year per facility.[111]

5.4.5.d. Recommendations for State Action

- Recommendation 14: States with ferroalloys production facilities should explore mechanisms for incorporating mercury emissions controls into source permits contingent on obtaining such authority in states where it is lacking (see recommendation 26).

5.4.6 Coke Production

Production of coke releases mercury contained in coal to the atmosphere. Metallurgical coke is produced by heating coal to temperatures as high as 2000˚C, driving off the impurities, including mercury, and leaving nearly pure carbon for use in steel production. Emissions from this sector are not well characterized. A 2002 U.S. EPA report estimated that 3.2 tons of mercury are contained in coal used for coke production annually, of which 0.7 tons is released to the atmosphere and 1.5 tons is disposed of in solid waste.[112]

Most coke oven production in the United States is at byproduct recovery facilities, in which coke oven gases are cooled and processed to generate a liquid condensate and a gas stream. The gas stream is treated and burned as a fuel, while the liquid condensate is processed to recover tar, tar derivatives and other chemicals. Three U.S. coke oven facilities, including the two newest, are non-recovery facilities, in which the coke oven gases are burned to produce energy, without any recovery of by-products. The non-recovery process is expected to be used on new steel mills.[113] Mercury emissions are thought to be highest at the non- recovery facilities; a European study found that the mercury from byproduct recovery coke plants is mostly recovered in the byproduct plant in the tar.[114]

U.S. coke production is concentrated in the Great Lakes states. Of the 16 coke production facilities operated by the top ten coke producers in the nation, according to the Energy Information Administration, ten facilities are located in the Great Lakes States. Half of U.S. coal consumption for coke production occurs in Illinois, Indiana, Michigan or Ohio, with additional unspecified levels of coal consumption for this purpose in New York and Pennsylvania.[115]

Table L

Top Ten Coke Producers[116]

[111] Personal Communication from Lars Petter Bingh, Executive Officer, Norwegian Pollution Control Authority, December 17 and 18, 2008. Tor Faerden, Norwegian Pollution Control Authority. Reduction of Mercury Emissions from Manganese Industry and Secondary Steel Industry. Convention on Long-range Transboundary Air Pollution Task Force on Heavy Metals, Fourth Meeting, 6 - 8 June 2007, Vienna (Austria). Downloaded on December 11, 2008 from http://www.unece.org/env/lrtap/TaskForce/tfhm/4thmeeting.htm.

[112] Barry R. Leopold. Use and Release of Mercury in the United States. U.S. EPA, Sustainable Technology Division, National Risk Management Research Laboratory. December 2002. EPA/600/R-02/104.

[113] AP 42, Fifth Edition, Volume I; Chapter 12: Metallurgical Industry, Section 12.2, Coke Production, May 2008.

[114] Fisher, R. *Progress in Pollution Abatement in European Cokemaking Industry.* In Ironmaking and Steelmaking (1992). Vol. 19, No. 6, page 450 and communication from Phil Mulrine, U.S. EPA Office of Air Quality Planning and Standards, February 18, 2009.

[115] Energy Information Administration. Annual Coal Report 2007. Table 26. http://www.eia.doe.gov/cneaf/coal/page/acr/table26.html

[116] Energy Information Administration. Annual Coal Report 2007. Table 25. http://www.eia.doe.gov/cneaf/coal/page/acr/table25.pdf

AK Steel Corp	Ohio	(KY)(OH)
DTE Energy Services	Michigan	(MI)
Drummond Company Inc		(AL)
Mittal Steel USA Burn Harbor	Indiana	(IN)
Mountain State Carbon		(WV)
Sloss Industries		(AL)
Sun Coke Company	Indiana, Ohio	(IN)(OH)(VA)
United States Steel Corporation	Illinois, Indiana, Pennsylvania	(IL)(IN)(PA)

5.4.6.a. Control Approaches

Sulfur and particulate control devices in use at most coke ovens achieve a small amount of mercury control. A recent study concluded that spray dryer adsorber and fabric filter baghouse configurations at non-recovery coke ovens achieve 16 to 30 percent control of mercury emissions, with greater than 80 percent control of particulate mercury, but limited control of oxidized and elemental mercury.[117]

5.4.6.b. Voluntary Programs

We are aware of no voluntary programs addressing mercury emissions from this sector.

5.4.6.c. Regulations

Federal regulations controlling emissions from coke ovens do not include mercury emissions limits. State mercury control efforts have focused on prospective coke plants seeking construction permits. For instance, in January 2008, the Ohio EPA granted a permit for the construction of a proposed FDS Coke plant in Oregon, Ohio. This permit limits total mercury emissions to 51 pounds per year at this non-recovery coke plant, including emissions that bypass the main stack, and requires sorbent trap mercury monitoring, with an option to use continuous mercury emissions monitoring. The permit also requires use of an activated carbon injection system which, together with the baghouse and SO2 scrubber, must achieve 90 percent mercury control. FDS can bypass these emissions controls up to eight days per year, during inspections and maintenance. Since this will be the first use of an activated carbon injection system at a U.S. coke plant, the permit also allows Ohio EPA to increase the mercury emissions limit and relax the 90 percent control requirement if the facility can demonstrate that they have optimized the control equipment and are still exceeding allowable emissions.[118]

Similarly, Gateway Energy and Coke has agreed to include activated carbon injection for mercury control at its prospective non-recovery coke production facility in Granite City, Illinois, after preliminary discussions about a construction permit with Illinois EPA. The goal would be 90 percent emissions control, and mercury emissions limits would not be incorporated into the permit until evaluation of control technology effectiveness was completed.[119]

5.4.6.d. Recommendations for State Action

[117] Lance S. Traves. Ghost in the Machine: Mercury Emissions from Non Recovery Coking Operations. Paper # 387, A&WMA'S 100th Annual Conference & Exhibition. Pittsburgh, Pennsylvania. June 26-29, 2007.
[118] Ohio EPA, Final Permit To Install Modification, Lucas County, Application No: 04-01360, Fac ID: 0448020084. January 31, 2008
[119] Illinois Environmental Protection Agency, Bureau of Air. Project Summary for a Construction Permit Application from Gateway Energy and Coke Company, LLC, for a Heat Recovery Coke Plant Located Adjacent to United States Steel's Granite City Works in Granite City, Illinois. 2007.

- Recommendation 15: States should require use of effective mercury emissions controls at new coke oven facilities, contingent on obtaining such authority in states where it is lacking (see recommendation 26).

5.5 Products and Processes that Deliberately Use Mercury

5.5.1. Background

Mercury is used in a variety of products for measuring temperature (thermometers) or pressure (manometers), for electrical switching (relays, thermostats, tilt switches, float switches, pressure switches), and as a preservative in medicines, personal care products and disinfectants. In addition, mercury-containing amalgam is used for dental fillings. Mercury used in these products can be released to the environment during the various stages of the product life cycle (production, transportation, manufacturing, use and disposal). Mercury-containing products result in significant releases. Product-related mercury emissions accounted for 32 percent of total mercury emissions nationwide in 2000.[120]

The Great Lakes Regional Collaboration's *Mercury in Products Phase-Down Strategy* examines the primary uses of mercury in products and recommends actions by Great Lakes states, tribes and municipalities to limit use of mercury in products, where warranted, and to limit mercury releases by improving the management of waste mercury products. The *Phase-Down Strategy* includes recommendations that would help address mercury emissions from diffuse sources, such as the breakage of mercury-containing products during use and disposal by reducing the quantity of mercury-containing products in circulation and by preventing the means of disposal most likely to result in environmental releases. This Mercury Emissions Reduction Strategy will, for the most part, not revisit the issues already addressed in the *Mercury in Products Phase-Down Strategy*, except to note that reducing the use of mercury in products and better managing mercury product waste is an effective strategy for reducing mercury emissions

However, separate sections of this Strategy do address the most significant sources of mercury emissions related to mercury-containing products, focusing not on mercury use or mercury waste management, but on air emissions controls and regulations that can be implemented for these sectors:

- Furnaces that melt metal scrap that includes mercury-containing devices (section 5.4.2).
- Incinerators that burn wastes that include mercury-containing medical devices, consumer products, industrial wastes, or biosolids contaminated with mercury as a result of mercury-containing products (section 5.7).

The remaining task for this section is to address smaller sources of mercury emissions related to mercury-containing products, including:

- Crematories
- Fluorescent Light Recyclers and Drum Crushers
- Land Application of Biosolids
- Manufacturers of products that contain mercury
- Mercury Recyclers
- Autoclaves

[120] Cain, A., Disch, S., Twarosk, C., Reindl, J. Case, R.C. 2007. Substance flow analysis of mercury intentionally used in products in the United States. Journal of Industrial Ecology 11(3):61-75.

5.5.2 Crematories

Cremation of corpses leads to mercury emissions primarily because of mercury in dental amalgam fillings. Dental amalgams are overwhelmingly the primary source of mercury in corpses. Approximately 700,000 corpses were cremated nationwide in 2003.

Quantification of mercury emissions from this sector is highly uncertain. Emission estimates based on a small amount of testing indicate that crematories are a relatively small source of mercury emissions. U.S. EPA estimates that crematories emitted 125 pounds of mercury in the Great Lakes states in 2002, spread among hundreds of crematoria. This estimate implies emissions of less than 0.5 grams of mercury per cremation. However, estimates based on a small number of emission tests may not be reliable because mercury emission rates would be expected to be highly variable and would depend on the number of amalgam fillings in the corpse being cremated at the time. Therefore, emissions testing based on an unrepresentative sample could be highly misleading. Moreover, a much higher estimate of crematory emissions can be derived via a mass balance, relying on estimates of the amount of mercury per filling and the amount of filling per corpse, or through use of emissions factors based on mercury emissions tests performed at European crematories. A survey of the literature on mercury emissions from crematoria concluded that each cremation most likely causes emissions of two to three grams of mercury.[121] Utilizing this estimate, emissions are most likely much higher. For example, Michigan estimates for 2002 crematory emissions are between about 130 and 190 pounds per year. Minnesota estimates their crematory emissions for 2005 at 80 pounds per year and are expected to increase to about 130 pounds per year by 2018 due to an increase in deaths and percent of bodies cremated.

Nationally, mercury emissions from crematoria are expected to increase in the coming decades. Cremation is increasingly common, representing 26 percent of U.S. deaths in 2000, up from six percent in 1975. Cremations are expected to increase in coming decades, to 43 percent by 2025.[122] Moreover, improved dental care means that more people die with their teeth, and fillings, intact. In the long term, mercury inputs into crematories are expected to decline because improved dental care is reducing the number of fillings that children need and because non-amalgam fillings are becoming increasingly popular. However, the trend through 2040 is expected to be increased mercury inputs to crematoria.

5.5.2.a. Control Approaches

There are two primary control approaches for reducing mercury emissions from crematoria: removal of amalgam fillings from corpses prior to cremation, and capturing mercury through emissions control technologies.

Tooth/Filling Removal: The most cost-effective and efficient method for control of mercury from crematories would be the removal of either the amalgam fillings or the whole tooth with the filling prior to incineration. However, this method has been vigorously opposed when presented as many people considered this a desecration to the body of the deceased. In 2003, the Washington State Department of Ecology required filling removal as a draft permit condition and was immediately denounced by local business groups. The Association of Washington Businesses and the Washington State Funeral Directors Association intervened in the permit negotiations and the draft condition was removed.

A poll taken by a Norwegian newspaper found that of 221 respondents, 40 percent were for filling removal and 53 percent were opposed, with 7 percent having no opinion. In the document summarizing comments received

[121] John Reindl, Summary of References on Mercury Emissions from Crematoria, January 23, 2007. Downloaded from http://www.ejnet.org/crematoria/reindl.pdf on October 30, 2008.
[122] Cremation Association of North America. 2002. Data reported at http://www.cremationoptionsinc.com/trends/ downloaded on October 30, 2008.

on the draft United Kingdom regulations, there were six main conclusions to the assessment, one of which was that removal of teeth or fillings is not acceptable. However, all listed comments received for the draft on the subject of filling removal recommended removal of fillings. A Swedish government report from the Chemical Inspectorate recommended removal of teeth as a control measure, but there was no report on the Swedish public's reaction. Public reaction to the Maine proposal for amalgam removal was overwhelmingly negative, with 72 percent opposed to the idea. Environmental groups have pressed for tooth removal as a simple solution rather than add-on control. Most crematory operators are against removal because it would most likely be their responsibility to find a dentist or orthodontist to perform the procedure.

Therefore, if filling removal were to be a required control method, it would have to be performed at a morgue or mortuary as part of the embalming or autopsy process prior to transporting the deceased to the crematory, perhaps under the direction of the state department of health. State law typically requires embalming to be performed by a licensed mortician only with approval from the relatives of the deceased, but not before obtaining permission from the county medical examiner if cause of death has not been determined. As a result, permission from the family of the deceased would be required for removal of the amalgam prior to cremation. Interestingly, current cremation practices require removal of other implants, such as artificial limbs, defibrillators, and pacemakers, prior to cremation as a safety measure. State laws in Texas, South Dakota, and Wyoming require removal of hazardous implants prior to cremation, although the Wyoming statute expressly forbids removal or possession of "dental gold or dental silver from deceased persons." So another method for requiring removal of fillings would be to require removal of hazardous materials from the deceased prior to cremation, and have the amalgam be considered hazardous. No data was found on the cost of filling removal, although the state employment vacancies webpage lists dentists' wages from $34 to $46 per hour. The Sierra Aftercare Center in California charges a fee of $50 for removal of a pacemaker prior to cremation. None of the Great Lakes states have a regulation in place that requires the removal of mercury dental amalgams prior to cremation.

Selenium Capsules: The Emcoplate Company from Sweden has developed the QuickSafe method for mercury removal. This method involves placing a QuickSafe ampoule atop the container prior to cremation. The ampoule contains selenium which is gasified during the cremation as the mercury is gasified. The selenium reacts with the mercury to form mercury selenide (HgSe) that will form crystals upon cooling and can then be collected via a baghouse, although the company's literature suggests that the HgSe could be emitted uncontrolled without negative environmental impacts. Testing results have shown up to 98 percent conversion/collection efficiency with this method. However, most crematories in the United States do not utilize a baghouse, or any emissions control device. Selenium is also a toxic metal, so uncontrolled emissions of selenium might be problematic. Toxicity data is lacking for HgSe, but the compounds would be considered a Hazardous Air Pollutant under Part 112 of the CAA as both a mercury compound and a selenium compound. One ampoule is required for a cremation, and the price per ampoule in 2002 was around $21.

Wet and Dry Scrubbing: There is only one crematory in the U.S. known to have wet scrubbers installed, which is at the Woodlawn Cemetery in the Bronx, New York. Testing was performed there in 1999 showing average mercury emissions of 1 g per cremation with a control efficiency of about 30 percent, although the report did not specify the number of fillings present in any of the bodies, the amount of mercury found in the scrubber water, or the speciation of the mercury. Wet scrubbing has been shown to remove mercury from the exhaust streams of other various processes, but the chemistry is such that only particulate and ionic mercury will be controlled, with very little effect on elemental or organic forms of mercury (if present). Information on the cost of the control system is unavailable. Miltec, a Norwegian firm, has developed a wet scrubber system with additive oxidizing agents for removal of mercury, sulfur, and particulates from crematories that have also been applied to waste incinerators and smelters. The company's literature claims a 90 percent guaranteed mercury control, with up to 98 percent efficiency possible. No data is readily available on cost. No cases of carbon

injection/fabric filter technology were found being used on crematories, although it would seem technologically feasible, as the methods of incineration for crematories are similar to those of medical waste incinerators.

Other Controls: Vermeulen Product Engineering has developed a catalytic system, preceded by a cyclone and filter for dust removal, for control of mercury as well as dioxins and furans. The company's literature claims 99.8 percent control efficiency in removing mercury. Data from an existing crematory report says this system would cost $300,000 to retrofit to an existing crematory and $175,000 on a new crematory. It is important to note that a new crematory costs about $80,000.

Non-Combustion Controls (Chemical Cremation): Chemical cremation, also known as "alkaline hydrolysis" or the trade name "Resomation," is a non-combustion based alternative to traditional cremation. The process involves destruction of the body with strong alkali in a water solution. Air emissions, including mercury, are negligible, but there is a sterile solution of salts, nutrients (phosphorus and nitrogen), and amino acids to dispose of (can go to wastewater treatment plants or be land-applied). One vendor of the equipment is Glasgow-based Resomation Ltd: http://www.resomation.com/. Mercury amalgams present in the body are easily removed after the process. Resomation yields bones that can be ground and given to the family, just as with traditional cremation. The Mayo clinic in Rochester, Minnesota has successfully used Resomation-type equipment since early 2006 and has had no technical problems. The U of Minnesota Veterinary school has a large Resomation-type unit for disposition of animals that works well (Wisconsin has a successful mobile unit to dispose of deer infected with Chronic Wasting Disease). The capital cost for a resomation facility is about $400,000, although operating costs are very low, perhaps lower than traditional cremation, which uses natural gas.

5.5.2.b. Existing State and Federal Programs

There are currently no state or federal regulations requiring mercury control from crematories. However, in Minnesota, a stakeholder group including the Minnesota Dental Association and major crematory operators in the state has agreed on a goal of reducing mercury emissions from crematories from an estimated 80 pounds in 2005 to 63 pounds in 2018 and 32 pounds in 2025. Actions to be taken in pursuit of this goal are:

- "Study emission rates and develop better understanding of future trends by 2010.
- Study abatement alternatives and emissions-control options between 2008 and 2011. (Abatement options include alkaline hydrolosis, pulling or decoronating teeth.)
- Study social issues of abatement options.
- Implement recommended alternatives to achieve reduction targets."[123]

5.5.3 Fluorescent Lamps

Several types of lamps contain mercury including high intensity discharge lamps, neon lamps, specialized lamps and fluorescent lamps. The focus of this section will be on fluorescent lamps because they are the most widely used. Elemental mercury is used in fluorescent lamps to help convert electrical energy into visible light with the use of phosphorus powder. Because of their energy efficiency, fluorescent lamps, primarily compact fluorescent lamps or lights (CFLs) are widely being promoted by states and federal agencies. Nationwide, fluorescent lamps account for an estimated 2-4 tons of mercury air releases, annually according to one study.[124] Another study estimated the air emissions in 2005 as one ton annually.[125] Some mercury-

[123] Minnesota Environmental Initiative. Strategy Framework for Implementation of Minnesota's Statewide Mercury TMDL. Minnesota Pollution Control Agency. July 7, 2008. See also Minnesota Environmental Initiative. Report On The Mercury TMDL Implementation Plan Stakeholder Process. Minnesota Pollution Control Agency, July 7, 2008. SEE http://www.pca.state.mn.us/air/mercury-reductionplan.html

[124] Aucott, M., McLinden, M. and Winka, M. 2004. Environmental assessment and risk analysis element research project summary – release of mercury from broken fluorescent bulbs.

containing lamps are recycled. For example in 2003, about 23 percent were recycled and the rest landfilled or incinerated, a major improvement in recycling rates from a decade earlier, when very few lamps were recycled.[126]

EPA encourages the recycling of all mercury lamps, however if recycling is not available in a geographic area EPA allows drum-top crushing (DTC) devices, though it has noted some of the difficulties that these devices can pose.[127] "…[T]he lamp drum-top crushers can release mercury vapors when operating.[128] Stationary or mobile facilities have also been permitted within the Great Lakes states. Lamp recycling facilities in Minnesota and Michigan have been required in permits to control mercury emissions with carbon filters, and in some cases air monitoring is required to demonstrate that the carbon filters are capturing the elemental mercury vapors. For some facilities stack testing for mercury is required.

These fluorescent light recycling sources are required to obtain permits in Michigan, Illinois and Indiana. However, Illinois and Indiana's air permits are driven by criteria pollutants such as particulate matter and therefore do not specifically address mercury emissions. While New York does not require an air permit for fluorescent light recycling facilities, it does require a registration certificate for operation. Minnesota requires lamp recyclers to obtain a waste-oriented compliance agreement to operate. As part of this agreement, the MPCA is working with the three facilities in the state to quantify and reduce air emissions.

EPA classified lamps as "universal waste" on January 6, 2000 (64 FR 36465),[129] and included them in 40 CFR Part 273.[130] Universal wastes were identified to facilitate the environmentally-sound collection and management of certain hazardous wastes. More flexible standards for storage and transportation are offered to handlers of universal wastes. EPA classifies fluorescent lamps as universal waste if the lights are being sent for recycling; otherwise the lamps are classified as hazardous waste.

Table M: Fluorescent Lamp Recyclers and Drum Top Crushers in the Great Lakes States
Estimated emissions from the Great Lakes states:

STATE	Fluorescent Light Recyclers	Drum-Top Crushers	Lbs/Year
IL	Fluorecycle, Inc. Ingleside - has air permit for crushing of high intensity discharge lamps and operates a distiller. PM emission limits that include Hg emissions are limited to nominal rates of 0.1 lb/hr and 0.44 tons/year. Facility reports PM emissions of 0.000008 tons or 0.16 lbs/year for 2008. Specialty Lighting & Lamp Recycling, Inc. Frankfort – no air permit is required River Shannon Recycling, Park Ridge	Allowed under the UWR.	~ < 1 lb
IN	Lighting Resources, Inc., Greenwood	No policy on drum-top crushers	

http://www.state.nj.us/dep/dsr/research/mercury-bulbs.pdf.

[125] Cain, A., Disch, S., Twarosk, C., Reindl, J. Case, R.C. 2007. Substance flow analysis of mercury intentionally used in products in the United States. Journal of Industrial Ecology 11(3):61-75.

[126] Association of Lighting and Mercury Recyclers (ALMR). 2004. National mercury-lamp recycling rate and availability of lamp recycling services in the U.S. http://www.nema.org/lamprecycle/docs/ALMR_capacity_statement.pdf

[127] U.S. EPA, Mercury Lamp Drum-Top Crusher Study. See http://www.epa.gov/waste/hazard/wastetypes/universal/drumtop/index.htm

[128] Lucas and Emery. 2006. Assessing Occupational Mercury Exposures During the On-site Processing of Spent Fluorescent Lamps

[129] http://www.epa.gov/EPA-WASTE/1999/July/Day-06/f16930.htm

[130] http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title40/40cfr273_main_02.tpl

	(estimated emissions 5.2 lbs/year-2007 stack test) Permitting threshold for PSD sources is 0.1 tpy (200 lbs/year) Driven by PM limit.		~ 5 lb/yr
MI	Source Permit Limit Lbs Emitted/yr Valley City (mobile), Grand Rapids 0.004 g/hr 0.231 lbs Greenlites (Cleanlites), (USA Lamp & Ballast Recycling), Mason 0.08 g/hr 1.5 lbs Reliable Relamping, Lowell 0.01 g/hr 0.19 lbs Greenlite Lamp Recycling 0.08 g/hr 1.55 lbs Battery Solutions, Wayne (collection only) Enviro, Inc. Birmingham (collection only)	One air permit issued with special conditions ex.5,000 lamps/yr with record keeping requirements. (Considering a general air permit for this source category)	~ 3 lb/yr
MN	Require all fluorescent lamps be recycled 3 facilities operate under haz waste mini permit Mercury Waste Solutions of Minnesota, Pine City Lamp Tracker, Roseville Green Lights Recycling, Blaine (Total estimate for all 3 facilities is 65 lbs – low confidence in this estimate) No air permits at this time.	State policy does not allow operation of DTCs	~ 65 lbs/yr
NY	Eastern Environmental, Port Chester (no air permit known) USA Lamp & Ballast Recycling, Inc. Milton (shipping area only, recycling plants are in Cincinnati, OH, Mason, MI & Spartanburg, SC) American Lamp Recycling, Wappingers Falls (estimated emissions ~< 1lb/yr) No air permits are required for these sources, but a registration certificate is required.	Regulated under UWR http://www.dec.ny.gov/chemical/8787.html	< 1 lb/yr
OH	Clean Harbors, Cincinnati Environmental Enterprises, Cincinnati e-Waste LLC, Hudson Environmental Recycling, Bowling Green Fluorescent Recycling Inc., Cleveland Gem City Environmental Recycling, Dayton Green Light LLC, Canton Gross Electric, Toledo Lightsout Inc./Harrington Electric, Cleveland Mayer Associates, Inc., Brewster Mercury Safe Solutions LLC,	No air permit required. Can be managed as hazardous or universal waste. If crushed, the lamps must be handled as hazardous waste. OH EPA recommends the recycling of all lamps.	

	Delaware Special Waste Systems, Miamisburg SunPro, Canton USA Lamp & Ballast Recycling, Cincinnati		
PA	American Waste Management, Corapolis AERC, Allentown Dlubak Glass Company, Natrona Hts Earth Protection Services, Lancaster H&H Lighting, Dallastown (No air permits)	Pennsylvania requires a hazardous waste treatment permit to crush hazardous waste lamps. PA does not allow the crushing to be done under the PA permit by rule provisions (e.g. generator treatment in containers or tanks) due to the risk involved; the lack of safe operating procedures; and worker exposure issues for mercury.	
WI	Lamp Recyclers, Inc, Green Bay Midwest Lamp, Madison Onyx Electronics Recycling, Port Washington Recycle Technologies, Inc., Waukesha No air permits for these sources because they fall below the emission threshold for mercury.	Wisconsin has no air regulations for lamp drum-top crushers and is covered under the UWR. Wisconsin does discourage the use of the drum-top crushers.	>5
Known Total Mercury Emissions from Permitted Lamp Recyclers:			80

5.5.3.a. Control Approaches

Elemental mercury emitted from such sources as fluorescent light recyclers can efficiently be controlled by carbon filters. Effectively, 90-100 percent of the mercury can be captured through the application of various types of carbon absorption control systems.[131] A combination of waste management plans that outline what waste is acceptable for processing in addition to effective control technology should achieve efficient capture of mercury emissions from these sources (see limits in table above).

5.5.4 Mercury Recyclers

In addition to lamp recyclers, several mercury recyclers are located within the Great Lakes states. The following facilities recycle or retort mercury that can then be re-used in products.

- DFG Mercury Corporation (formerly DF Goldsmith Chemical and Metal Evanston, IL)
  - Air permit issued based on negligible mercury emissions from the mercury vacuum distillation process. Mercury emissions are limited to rates of 0.1 lb/hour and 0.44 tons based on a maximum distillation process throughput of 35 pounds/hour and 153.3 tons/year. DFG Mercury reported mercury emissions of 0.07 tons or 140 pounds/year for the 2008 calendar year. The air permit requires DFG Mercury to maintain monthly records of mercury-containing raw materials received and mercury emissions.
- Mercury Technologies of Minnesota (Pine City) (Mercury emissions are unknown.)
- Mercury Waste Solutions, Union Grove, WI (Believed to be the largest mercury recycler in the country. Reported mercury emissions are 3 pounds/year.)
- Bethlehem Apparatus Co Inc., Hellertown, PA (The company has an operating permit which was issued in 1998 and the renewal is pending due to certain issues. The operating permit has only odor related conditions and no mercury emissions conditions are included in the air permit. No mercury emissions are reported.)

[131] EPA, 1994. Evaluation of mercury emissions from fluorescent lamp crushing – control technology center. Sponsored by Emission Standard Division Office of Air Quality Planning and Standards U.S. Environmental Protection Agency Research Triangle Park, NC 27711. February 1994. EPA-453/R-94-018.

5.5.5 National Export Ban

On October 15, 2008 President Bush signed into law a bill that was introduced by President Elect Obama to ban the export of elemental mercury from the United States. The Mercury Export Ban Act of 2008, prohibits the transfer of elemental mercury by federal agencies, bans U.S. export of elemental mercury by January 1, 2013, and requires the Department of Energy to designate and manage an elemental mercury long-term disposal facility.

MDEQ's Mercury Strategy Report of 2008 recommends that MDEQ investigate and explore the development of a mechanism to ensure that mercury collected or recovered in Michigan is used only for essential uses and to explore the current barriers regarding exportation of nonessential mercury uses to other states or countries.

5.5.6 Land Application of Biosolids

The term "biosolids" is defined as solid, semisolid, or liquid residues generated during primary, secondary, or advanced treatment of domestic sanitary sewage through one or more controlled processes that reduce pathogens and attractiveness to vectors (flies, mosquitoes, rodents). These processes include, among others, anaerobic digestion, aerobic digestion, and lime stabilization. Biosolids (also known as sewage sludge) are used to enhance agricultural and forestry production. Almost all biosolids that are land applied are used to grow crops on sites at agronomic application rates approved by state agencies. Biosolids are also used to provide nutrients and soil conditioning in mine reclamation programs, tree farms, and forest lands.

Once mercury enters a wastewater treatment plant (WWTP), most of it concentrates in wastewater biosolids during treatment which is disposed of by land spreading. Some of this land-applied mercury may, over time, be volatilized to the atmosphere which can then be deposited into lakes and streams, methylated, and ingested by fish, eventually reaching wildlife and humans.

In 2003, in Michigan the average mercury concentration in biosolids was 1.9 ppm and 71,900 dry tons were land applied resulting in an estimated 1,300 pounds of mercury released to the environment, some to the atmosphere.[132] In Minnesota, about 50,000 dry tons of biosolids are land applied each year. In Minnesota, biosolids averaged 3.6 ppm of mercury in 1990, 1.8 ppm in 1995, 1.4 ppm in 2000, and 0.7 ppm in 2005. Air emissions from these sludge applications were an estimated two pounds state-wide in Minnesota in 2005. In both Michigan and Minnesota the mercury content of the sludge has been declining over time. Both states' estimates assume that 1 percent of the mercury applied to the surface of the land volatilizes within a year, but neither attempted to calculate any carryover from previous years. Minnesota estimates that future emissions from land-applied sludge are projected to decrease by 50 percent by 2018 because of continued efforts to reduce mercury discharge to sanitary sewers, especially by dentists.

5.5.7 Manufacturing of Products that Contain Mercury

The Interstate Mercury Education & Reduction Clearinghouse (IMERC) Mercury-Added Products Database was used to facilitate identification of facilities that could potentially release mercury from their process. It should be noted that the database reports on uses of mercury, not specifically air emissions.

The IMERC Mercury-Added Products[133] Database presents information submitted to the IMERC-member states on the amount and purpose of mercury in consumer products. The database is intended to inform consumers, recyclers, policy makers, and others about:

- Products that contain intentionally-added mercury

[132] Michigan State Work Group, 2008
[133] http://www.newmoa.org/prevention/mercury/imerc/notification/#note#note

- The amount of mercury in a specific product
- The amount of mercury in a specific product line sold in the US in a given year
- Manufacturers of mercury added products.

The information in this database was submitted through IMERC by or on behalf of product manufacturers in compliance with laws in the states of Connecticut, Louisiana, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. These notification requirements have been in effect for products manufactured or distributed beginning in January 2001 by Northeast Waste Management Officials' Association (NEWMOA).

IMERC Background

Starting in 1999 the states in the Northeast and other parts of the country actively began to pursue enactment of legislation focused on reducing mercury in products and waste. In the Northeast these efforts focused on enactment of provisions of the Mercury Education and Reduction Model Legislation. Copies of the Model Legislation are available on this website at http://www.newmoa.org/prevention/mercury/final_model_legislation.htm.

The Great Lakes states that are members include:

- **Illinois -** http://www.epa.state.il.us/mercury/mercury-illinois.html
- **Minnesota -** http://www.pca.state.mn.us/air/mercury.html
- **New York -** http://www.dec.ny.gov/chemical/285.html

Appendix F shows the companies in the Great Lakes states that manufacture products that contain mercury.

Manufacturer Take-Back Programs

Product manufactures, notably thermostat producers, have established programs to collect their mercury added products at the end of their useful life. The Thermostat Recycling Corporation (http://www.nema.org/gov/ehs/trc/), a not-for-profit corporation founded and operated by thermostat manufacturing companies, facilitates the nationwide collection of all brands of used, wall-mounted mercury-switch thermostats so that the mercury can be purified for re-use. Collection takes place through HVAC wholesale outlets, HVAC contractors that meet certain size or location criteria, and local household hazardous waste facilities.

The Thermostat Take-Back program was initiated in Minnesota as a result of legislation requiring thermostat manufacturers to ensure that products removed from service are recycled. The same requirement applies to relays although no program has been established by the manufactures.[134]

5.5.8 Autoclaves

An **autoclave** is a pressurized device[135] designed to superheat steam under pressure to achieve decontamination. Autoclaves are used in the health care and dental industry to sterilize reusable equipment so bacteria, viruses and fungi are destroyed as well as to decontaminate medical waste to render it safe for routine handling as solid waste. Treatment using autoclaves as well as microwaves can result in fugitive emissions of mercury into the building and may also result in mercury in the effluent water. Fugitive mercury emissions were detected at operating autoclaves in both Minnesota and Michigan. Control is by carbon filters. Limited

[134] Minnesota Statutes 116.92 Sub. 5
[135] http://en.wikipedia.org/wiki/Pressure_vessel

information exists on the number of medical autoclaves operating in the Great Lakes Basin. Michigan has two operating autoclaves that require capture of fugitive mercury emissions, Pennsylvania also has two commercial infectious waste autoclaves operating, and Minnesota has one with no known mercury emission reduction requirements. Wisconsin reports that they do not have any known operating medical autoclaves in operation.

5.5.8.a. Control Approaches

Elemental mercury emitted from autoclaves can efficiently be controlled by carbon adsorption control systems. Other methods can be used, but would not be as cost affective. In addition to mercury, this control method should achieve 98 percent removal efficiency for volatile organic compounds. Autoclaves have a high temperature, high moisture discharge. This is not ideal for carbon control. It is necessary to condition the gas stream so that it is less than 140 degrees Fahrenheit (<100ºF is ideal) and less than 50 percent moisture entering the carbon. The gas stream also needs to have sufficient contact time (one to two seconds) to achieve effective control. A combination of waste management plans that outline what waste is acceptable for processing in addition to effective control technology will minimize mercury emissions from these sources.

5.5.8.b. Existing State and Federal Programs

There are currently no state or federal regulations requiring mercury control from autoclaves. In Michigan there is a permit exemption for sterilization equipment at medical and pharmaceutical facilities, Air Pollution Control Rule 336.1281(i). Michigan requires air use permits for all commercial medical waste autoclaves. Also, due to the type of waste being treated and the potential for mercury emissions, best available control technology for toxics (T-BACT) for mercury has been established for this source category in Michigan. Commercial medical waste autoclaves must be equipped with a mercury emission control system, designed to capture and minimize the emissions of mercury from all potential emission points.

5.5.9 Recommendations for State Action

Because disposal of mercury-containing products results in significant releases of mercury into the environment, it is important to limit the use of mercury in products. The following recommendations address mercury-containing products and those sources that process or dispose of such mercury-containing items. Implementing such recommendations will facilitate reductions of mercury in the waste streams destined for municipal waste landfills and incinerators, sewage sludge incineration and/or biosolid land applications. Specific recommendations should help reduce emissions from crematories, mercury product manufacturing, lamp disposal and autoclaves.

- Recommendation 16: The Great Lakes states should continue to implement the recommendations contained within the Great Lakes Regional Collaboration's *Mercury in Products Phase-Down Strategy* that address mercury bans in products, mandatory recycling and participation in national or regional clearinghouse efforts on mercury product stewardship.[136]
- Recommendation 17: The Great Lakes states should work with the crematory industry to better understand the emission levels from crematories and explore control options to decrease mercury emissions.
- Recommendation 18: The Great Lakes states should recommend the recycling of all mercury-containing lamps, following U.S. EPA's lead. Recycling practices, including accumulation, transportation and processing should conform to industry best practices (as reported by the Association of Lamp and Mercury Recyclers). If the operation of lamp drum-top crushers is permitted within the Great Lakes states, specific conditions should be met. These include, but are not limited to, operation away from sensitive populations such as hospitals, nursing homes and schools; operation with proper

[136] http://www.glrc.us/documents/DraftMercuryPhaseDownStrategy.pdf

controls such as carbon filters. Operators should follow the BMPs established by the Association of Lighting and Mercury Recyclers The Great Lakes states should require best available control technology for mercury emissions in air permits for stationary or mobile sources that recycle mercury-containing lamps. Where permitting authority is not available, states should work through P2 and/or compliance assistance programs to achieve reductions.

- Recommendation 19: The Great Lakes states should require best available control technology for mercury emissions in air permits for stationary or mobile source that recycle mercury-containing lamps. Where permitting authority is not available, state should work through P2 and/or compliance assistance programs to achieve reductions.
- Recommendation 20: The Great Lakes states should encourage manufacturing facilities that manufacture products that contain mercury, including switches, relays, dental amalgams, to find environmentally-preferred alternatives. If no alternatives exist, states should encourage manufacturers to control mercury using best management practices and eventually consider regulating with best available control technology via air permits. States may also consider encouraging or requiring manufacturers to implement take-back programs for mercury-containing devices similar to the Thermostat Recycling Corporation's thermostat reverse distribution program.[137]
- Recommendation 21: The Great Lakes states should require autoclaves that process /sterilize waste from health care and dental facilities to implement a waste management plan that assures removal of mercury from the waste stream. States should also consider requiring mercury controls through an air permit or other means, as deemed necessary.

5.6 Portland Cement Manufacturing

5.6.1 Background

Portland cement is described by the U.S. EPA's AP-42[138] as a fine powder, gray or white in color that consists of a mixture of hydraulic cement materials comprising primarily calcium silicates, aluminates and aluminoferrites. More than 30 raw materials are known to be used in the manufacture of Portland cement, and these materials can be divided into four distinct categories: calcareous, siliceous, argillaceous, and ferriferous. These materials are chemically combined through pyroprocessing and subjected to subsequent mechanical processing operations to form gray and white Portland cement. Gray Portland cement is used for structural applications and is the more common type of cement produced. White Portland cement has lower iron and manganese contents than gray Portland cement and is used primarily for decorative purposes.

The manufacturing of Portland cement includes the process of transforming calcium carbonate and clays into calcium oxide under high temperature (1600 to 1800 ^{o}F) in a kiln. Calcium oxide reacts with added silica material and added aluminates to form calcium silicate "clinkers," in the size range of 0.125 to 2 inches in diameter. Additional reactions occur with dicalcium silicate and calcium oxide to form tricalcium silicates. Approximately half of the final Portland cement product is tricalcium silicates and the remainder is dicalcium silicates and dicalcium aluminates and ferrites.

The high temperatures required in the kiln are achieved predominately by the firing of coal or hazardous waste. The kiln length and quantity of fuel used are to some extent dependent on if the process is considered a dry or wet process Portland cement manufacturing facility. Wet processes require kilns to burn more fuel to in order to dry out the material prior to the calcination process.

5.6.1.a. Processes that emit mercury

[137] http://www.nema.org/gov/ehs/trc/.
[138] U.S. EPA AP-42, Portland Cement Manufacturing, Final Section, January 1995

Five different processes are used in the Portland cement industry to accomplish the pyroprocessing step: the wet process, the dry process (long dry process), the semidry process, the dry process with a preheater, and the dry process with a preheater and precalciner. Each of these processes accomplishes the physical/chemical steps defined above. However, the processes vary with respect to equipment design, method of operation, and fuel consumption. Generally, fuel consumption decreases in the order of the processes listed.[1]

Mercury is emitted from the burning of coal and hazardous waste, the pyroprocessing of limestone and clay, and the addition of aluminates. The needed addition of aluminum can be achieved with the introduction of bauxite as a raw material. In response to controlling costs, source owners have the option of adding silicates and aluminates in the form of coal derived fly-ash from electric utilities. Not all Portland cement facilities utilize coal derived fly-ash in the pyroprocess.

In May of 2007, the U.S. EPA requested data from the Portland cement manufacturing industry as authorized under §114 of the Clean Air Act. The U.S. EPA requested general facility information, mercury and total organic carbon (TOC) contents of kiln feed material and mercury and total hydrocarbon (THC) test data.

5.6.1.a.i. Mercury Emissions from Primary Fuel, Coal or Hazardous Waste

Of the data retrieved from the U.S. EPA docket, 20 facilities had a mean mercury coal concentration of 0.08 ppm with a range of 0.01 to 0.24 ppm. This range is similar to the coal data analyzed for the Clean Air Mercury Rule. The Mercury Study reported nationwide emissions of mercury which fire hazardous waste at 2.9 tons per year.

5.6.1.a.ii. Mercury Emissions from Coal Derived Fly-Ash

Of the 17 facilities supplying data to the U.S. EPA, five facilities supplied data on the mercury content of coal derived fly-ash, resulting in a mean value of 0.323 with a range of 0.15 to 0.63 ppm.

Another study investigating the potential increase in mercury content of coal derived fly-ash resulting from the control of mercury emissions from coal-fired electric utility generators due to state regulations and upcoming federal regulation identified the use of coal fly-ash in the manufacture of Portland cement as potential significant sources of mercury emissions from this source category. Data from the Energy and Environment Research Center (EERC) at the University of North Dakota, found the following[139]:

Table N

Summary of Complete Project Fly Ash Sample Set

Sample Type	No. of Samples	Total Hg Range, ppm
Fly Ash (no Hg control)	40	0.005–2.03
Fly Ash–Activated Carbon (Hg control, collected in primary pollution control device)	22	0.147–5.8
Fly Ash–Activated Carbon (Hg control, collected after primary	5	17.7–120

[139] Leaching Characteristics of Fly Ash-Activated Carbon from Mercury Control Technologies, prepared for the government-funded Energy and Environment Research Center (EERC) at the University of North Dakota, December 2004

pollution control device))

The second fly-ash activated carbon data set shows that the addition of activated carbon after the primary pollution control device results in higher mercury content fly-ash. The intention of this pollution control arrangement is to preserve the ability to sell the fly-ash product in the initial pollution control device and capture mercury in the second device. The smaller mass of captured fly-ash in the second device results in a higher concentration of mercury in the fly-ash.

In addition to the two above findings on mercury concentration of coal derived fly-ash, the U.S. EPA reported on findings of 16 fly ash samples and reported a range of 0.002 to 0.685 ppm.[140]

5.6.1.a.iii. Mercury Emissions from Primary Raw Materials

Based upon 14 studies reported by the Portland Cement Association[141], the mercury content of limestone can vary by a factor of 100. Studies found the mercury concentration of limestone at a range of 5 ppb to 460 ppb, with a median value of 40 ppb. Clay had a larger range of 5 to 3000 ppb with a median value of 150 ppb.

5.6.1.b. Sector mercury emissions, nationally, and within Great Lakes

Depending on the input to the cement kiln, emissions of mercury from a cement manufacturing plant can range from 1 to 400 pounds of mercury. The table below represents data reported to the 2006 TRI.

Table O

Facility	City	State	Pounds per year
BUZZI UNICEM USA OGLESBY	OGLESBY	IL	4
ILLINOIS CEMENT CO	LA SALLE	IL	10
LAFARGE MIDWEST INC JOPPA PLANT	GRAND CHAIN	IL	1
ST. MARYS CEMENT INC DIXON PLANT	DIXON	IL	17
BUZZI UNICEM USA - GREENCASTLE PLANT	GREENCASTLE	IN	130
ESSROC CEMENT CORP	LOGANSPORT	IN	85
ESSROC CEMENT CORP	SPEED	IN	176
LEHIGH CEMENT CO	MITCHELL	IN	159
LAFARGE BUILDING MATERIALS INC.	RAVENA	NY	414
LEHIGH NORTHEAST CEMENT CO – GLENS FALLS PLANT	GLENS FALLS	NY	12

[140] US EPA Federal Register 71, No.244 page 76525

[141] V.C. Johansen and G.J. Hawkins, Mercury Emission and Speciation from Portland Cement Kilns, PCA R&D Serial No. 2567a Portland Cement Association 2003

ST LAWRENCE CEMENT CO	CATSKILL	NY	51
HOLCIM (US) INC. - DUNDEE PLANT	DUNDEE	MI	117
LAFARGE MIDWEST INC.	ALPENA	MI	417
ST MARYS CEMENT INC (U.S.)	CHARLEVOIX	MI	56
LAFARGE NA (INCLUDING SYSTECH ENV. CORP.)	PAULDING	OH	36
CEMEX INC FAIRBORN CEMENT PLANT	XENIA	OH	24
ARMSTRONG CEMENT & SUPPLY CORP	CABOT	PA	17
BUZZI UNICEM STOCKERTOWN PLANT	STOCKERTOWN	PA	9
CEMEX, INC.	WAMPUM	PA	70
ESSROC CEMENT CORP	BESSEMER	PA	151
ESSROC CEMENT CORP	NAZARETH	PA	163
JAMES HARDIE BUILDING PRODUCTS INC BLANDON PLANT	BLANDON	PA	NA
KEYSTONE CEMENT CO	BATH	PA	105
LAFARGE N.A. WHITEHALL PLANT	WHITEHALL	PA	61
LEHIGH CEMENT CO	YORK	PA	16
LEHIGH CEMENT CO - EVANSVILLE	FLEETWOOD	PA	86
TOTAL REPORTED MERCURY EMISSIONS			**2,387**

The Great Lakes States reported a total of 4,533 pounds of mercury in the 2002 NEI from the Portland cement manufacturers and another 1,898 pounds per year from facilities using hazardous waste as a primary fuel.

5.6.1.c. Control Approaches

The control of mercury from the Portland cement manufacturing sector is similar to the effectiveness from the control requirements for the coal-fired electric utility sector. The more effective the control for sulfur dioxide and particulate the facility employs, the better the control of mercury will be attained.

The particulate control devices found at the majority of Portland cement manufacturing facilities, identified in the Maximum Achievable Control Technology (MACT) floor analysis, were electrostatic precipitators (ESP) and fabric filters. The operating temperature of an ESP for cement kilns is typically in the range of 400 ^{o}F. At this temperature, the capture efficiency is essentially zero for semi-volatile metals such as mercury. Sources utilizing fabric filters would have an inherent degree of control of mercury as the filter cake builds with unburned carbon and captures mercury passing through the filter bag.

The reduction of mercury containing additives to the cement making process, such as the use of mercury laden coal derived fly-ash, is one approach to reduce mercury emissions. If the use of coal derived fly-ash is to continue, its use should be limited to fly-ash which has been tested to have mercury levels comparable to other required additives for the needed aluminum and silica concentrations.

5.6.2 Existing and Prospective Federal Regulation

The National Emission Standards for Hazardous Air Pollutants (NESHAP) for Source Categories; Portland Cement Manufacturing Industry; Final Rule was implemented on Jun 24, 1999. As discussed in the preamble to the NESHAP regulation, no standards were adopted for mercury and hydrogen chloride because the

MACT floor has been determined to be no control and the beyond the MACT floor technology controls were not cost effective (docket item II–B–67).[142]

On December 2, 2005, based upon lawsuits brought upon the U.S. EPA, the United States Court of Appeals for the District of Columbia Circuit (DC Circuit) remanded parts of the NESHAP for the Portland cement manufacturing industry to EPA to consider, among other things, setting maximum achievable control technology (MACT) floor standards for hydrogen chloride, mercury, and total hydrocarbons (THC), and beyond-the-floor standards for metal hazardous air pollutants. The court specifically rejected the argument that EPA was excused from establishing floor levels because no "technology based pollution devices" exist to control the HAP in question.

On July 18, 2006, the U.S. EPA reopened the comment period for certain portions of the proposed amendments to the NESHAP for the Portland Cement Manufacturing Industry, published on December 2, 2005, with respect to the proposed emission standards for mercury, hydrogen chloride, and total hydrocarbons. A final rule was promulgated on December 20, 2006 and the U.S. EPA concluded:

> "that the standards for mercury for all existing cement kilns are to remove accumulated mercury-containing cement kiln dust from the system at the point product quality is adversely affected. The standard for new sources is to utilize this same work practice, and in addition, to meet a standard of either 41 μg/dscm or a site-specific limit based on performance of a properly designed and operated wet scrubber. In addition, we are banning the use of utility boiler fly ash in cement kilns where the fly ash mercury content has been increased through the use of activated carbon or any other sorbent unless the facility can demonstrate that the use of that fly ash will not result in an increase in mercury emissions over baseline emissions (i.e., emissions not using the mercury increased fly ash). The facility has the burden of proving there has been no emissions increase over baseline. This requirement, adopted as a beyond-the floor control, applies to both existing and new sources."

At the same time EPA issued the December 20, 2006 final rule, EPA on its own initiative agreed to reconsider parts of the final regulation. The changes included: (1) addressing the mercury emission standard for new and existing sources, (2) addressing the new and existing source standard banning the use of certain mercury-containing fly-ash at cement kilns, and (3) the new source standard for total hydrocarbons.

On May 9, 2009, EPA proposed new emissions standards for mercury and total hydrocarbons. In addition, EPA made changes to the particulate matter (PM) standard by changing the compliance calculation to pounds of PM per clinker produced as compared to pounds of PM per feed rate. The addition of a hydrochloric acid standard was proposed and the opacity requirement was vacated from the December 21, 2006 final rule.

The proposed mercury emission limit for existing cement kilns and inline kilns/raw mills is 43 pounds per million tons of clinker produced and for new cement kilns and inline kilns/raw mills is 14 pounds per million tons of clinker produced. Both proposed limits are based upon a 30 day rolling average. EPA is also proposing to eliminate the restrictions on the use of mercury containing fly-ash which was promulgated in the December 20, 2006 final rule. EPA is also proposing to determine compliance with the use of continuous emission monitors (CEMs). While no mercury CEMs are currently in operation at cement kilns in the United States, there are currently thirty-four mercury CEMs operating at cement kilns outside the United States.

5.6.3 Existing and Prospective State Regulation

[142] Docket No. A-92-53 Portland Cement Manufacturing NESHAP Category II Items Considered in Developing Proposal Subcategory II-A EPA Studies or Contractor Reports

At the present time, no States in the region have regulations for the Portland cement industry with respect to emissions of mercury emitted from the pyroprocessing process.

5.6.4 State and Federal Voluntary Programs Affecting Emissions from this Sector

At the present time, no States in the region have voluntary programs for the Portland cement industry with respect to emissions of mercury emitted from the pyroprocessing process.

5.6.5 Recommendations for State Action

Recommendation 22: States with cement production facilities should explore mechanisms for incorporating mercury emissions controls into source permits contingent on obtaining such authority in states where it is lacking (see recommendation 26).

5.7 Waste Incinerators

5.7.1 Background

Incineration is widely used to reduce the volume of municipal solid waste, to reduce the potential infectious properties and volume of medical waste, and to reduce the potential toxicity and volume of hazardous chemicals and biological waste. Waste incineration has historically accounted for a significant portion of mercury emissions. Mercury emission reductions from waste incineration have occurred over the years through the implementation of emission control technology and pollution prevention practices to reduce mercury content in products that eventually become a part of the waste stream.[143]

5.7.1.a. Source Description

The four waste types commonly treated by incineration include municipal waste, medical waste, hazardous waste and sewage sludge. The goal of a well-designed waste incinerator is to operate in a manner that all organic, and many inorganic wastes are broken down, allowing reactions between the volatile components of the waste and the oxygen and nitrogen in air, producing carbon dioxide, and water vapor. Optimal design and operation of an incinerator requires attention to temperature, turbulence of combustion gases, and combustion gas residence time at temperatures sufficient to achieve complete combustion. When combustion reactions do not proceed to their fullest extent, other substances are created. Specific substances of concern include carbon monoxide, nitrogen oxides, sulfur oxides, hydrogen chloride, cadmium, lead, mercury, chromium, arsenic, beryllium, dioxins and furans, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons. These air pollutants are formed during waste incineration or are present in the waste stream fed to the incinerator.[144]

Current technologies include high-efficiency burner systems, waste-pretreatment practices such as shredding and blending, and oxygen enrichment to promote good combustion. Considerable attention has also been given to measurement and control of key process operating conditions to allow better control of the whole combustion process. Incinerator designs also vary according the type of waste to be combusted with the following designs currently in use for each waste type.

Municipal Solid Waste Incineration - Municipal solid waste furnace designs have evolved over the years from simple batch-fed, stationary refractory hearth designs to continuous feed, reciprocating (or other moving, air-cooled) grate designs with waterwall furnaces for energy recovery. There are 3 main classes of technologies used to combust municipal solid waste: mass burn, refuse-derived fuel (RDF), and modular combustors. The newer municipal solid waste incinerators are predominantly mass burn, waste-to-energy plants that produce steam for electric power generation.

[143] Waste Incineration and Public Health - National Research Council - 2000
[144] Waste Incineration and Public Health - National Research Council - 2000

Medical Waste Incineration - Medical wastes are commonly burned in controlled air incinerators that have two chambers and are also equipped with an afterburner. In the first stage, waste is fed into the primary combustion chamber, which is operated with less than the stoichiometric amount of air required for combustion. In the primary (starved-air) chamber, the low air-to-fuel ratio dries and facilitates volatilization of the waste, and most of the residual carbon in the ash burns. Secondary chamber temperatures are higher than primary chamber temperatures to completely combust the volatiles. Depending on the heating value and moisture content of the waste, additional heat may be needed which is usually provided by auxiliary burners located at the entrance to the secondary chamber to maintain desired temperatures.

Hazardous Waste Incineration - The predominant hazardous-waste incinerator designs are rotary kilns, fluidized beds, liquid injection and fixed hearth.

Sewage Sludge Incineration - Multiple hearth furnaces, originally developed for mineral ore roasting, are commonly used to treat sewage sludge. Multiple hearth furnaces are operated with afterburners to reduce odors and concentrations of unburned hydrocarbons.[145]

5.7.1.b. Control Approaches

Heavy metals in waste are not destroyed by incineration. The amount of mercury emission is determined largely by the mercury feed rate and by whether mercury specific air pollution control devices are used. Conventional air pollution control devices, such as fabric filters, ESPs, inertial-impaction scrubbers, and other wet scrubbers are only partially effective for mercury removal. Traditional wet-scrubbers provide moderate (20-90 percent) mercury control efficiencies. High efficiency (>90 percent) mercury removal has been achieved by many municipal solid-waste combustors and a smaller number of hazardous-waste and medical-waste incinerators by powdered activated-carbon injection in tandem with alkaline reagents upstream of dry particle collection devices, usually fabric filters. Mercury emissions from waste incinerators can be reduced by preventing mercury from entering the waste stream by separation and eliminating mercury in products.[146]

Great Lakes States Sources and Emissions

In the Great Lakes States, waste incineration contributed 2.9 of mercury emissions annually, eight percent of total stationary source emissions. Nationwide, mercury emissions from this sector declined dramatically in the 1990s, with a 97 percent reduction from medical waste incinerators and a greater than 91 percent reduction from municipal waste combusters between 1990 and 1999.[147] Mercury emissions from this sector are continuing to decline, as the mercury content of municipal and medical waste falls.

5.7.2 Existing and Prospective Federal Regulation

EPA has promulgated new source performance standards (NSPS) and emission guidelines for large and small municipal waste combustors, medical waste incinerators, commercial and industrial solid waste incinerators and other solid waste incinerators that include mercury emission limitations. [148] Both the NSPS and the emission guidelines for waste incinerators, established under sections 111 and 129 of the Clean Air Act, require mercury emission limitations that would be equivalent to Maximum Achievable Control Technology (MACT) as outlined in section 112, Hazardous Air Pollutants, of the Clean Air Act. Typically the NSPS and

[145] AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors, Volume I: Stationary and Area Sources, U.S. EPA
[146] Waste Incineration and Public Health - National Research Council - 2000
[147] USEPA, EPA's Roadmap for Mercury, July 2006, EPA-HQ-OPPT-2005-0013.
[148] U.S. EPA Technology Transfer Network Air Toxics Web Site – Rules and Implementation for National Emission Standards for Hazardous Air Pollutants

the emission guidelines include emission limitations for particulate matter, opacity, sulfur dioxide, hydrogen chloride, dioxin, nitrogen oxides, cadmium, lead, carbon monoxide, and mercury.

NSPS are federal regulations that apply directly to new sources and generally become effective upon rule proposal. Emission guidelines do not directly regulate waste incinerators, but rather, establish requirements for states to develop state plans, usually including state regulations, that require EPA review and approval. Once approved, state plans become federally enforceable. The requirements for existing sources become effective no later than five years after the emission guidelines are promulgated. The NSPS and emission guidelines must be reviewed every five years as required by the Clean Air Act.

LARGE MUNICIPAL WASTE COMBUSTORS

In addition to emission limitations, the NSPS for large municipal waste combustors include operator training and certification, development of plans addressing materials separation and recycling, a siting analysis, and monitoring, testing and reporting requirements. It should be noted that materials separation and recycling plans are a product of local citizen participation without requirements to establish goals or target specific materials like mercury products. The mercury emission limitation for new large municipal waste combustors is 0.080 milligrams per dry standard cubic meter (*80 micrograms per dry standard cubic meter*) or 85 percent reduction in mercury. The mercury emission limitation presumes the use of activated carbon injection as the default mercury control technology. The emission guidelines apply to existing large municipal waste combustors that commence construction, modification, or reconstruction on or before September 20, 1994. Existing units must achieve the same mercury emission limitation as new sources. However, existing units do not have a materials separation and recycling plan requirement.

EPA was required to amend its emission guidelines and NSPS for municipal waste combustors proposed in September 1994, based on a court order. As a result, these regulations only apply to those waste incinerators with a capacity to combust more than 250 tons per day of municipal solid waste. The large municipal waste combustor requirements were promulgated in August 1997. Small municipal waste combustors were addressed in a separate action by EPA.

On May 10, 2006, EPA published amendments to the regulations for large municipal waste incinerators addressing the required five-year review. Included in the amendments was a proposal to limit mercury emissions to 50 micrograms per dry standard cubic meter effective April 28, 2009. The existing 85 percent mercury removal alternative remains unchanged.

SMALL MUNICIPAL WASTE COMBUSTORS

The NSPS and emission guidelines for small municipal waste combustors apply to units with a daily waste combustion capacity of 35 tons but no more than 250 tons. These requirements were proposed on August 30, 1999 and were promulgated on December 6, 2000.

Requirements for new small waste combustors include a materials separation plan, a siting analysis, operator training and certification, operating requirements, mercury stack emission testing, continuous emission monitoring and monitoring of carbon feed rate for activated carbon injection mercury control systems. Mercury emissions are limited to 0.080 milligrams per dry standard cubic meter (*80 micrograms per dry standard cubic meter*) or 85 percent reduction in mercury. New units are the units constructed after August 30, 1999.

Small waste combustor emission guidelines affect units in operation on or before August 30, 1999. Existing units must achieve the same mercury emission limitation as new sources. Other requirements include operator

training and certification, operating requirements, mercury stack emission testing, continuous emission monitoring and monitoring of carbon feed rate for activated carbon injection mercury control systems.

HOSPITAL/MEDICAL/INFECTIOUS WASTE INCINERATORS

EPA anticipated that the emission guidelines and NSPS for hospital/medical/infectious waste incinerators, promulgated in September 1997, would result in the closure of a majority of existing hospital/medical/infectious waste incinerators and that very few new incinerator installations would ensue. New units are those incinerators constructed after June 20, 1996.

The NSPS include monitoring and testing requirements, a siting analysis, waste management plan, and trained and qualified operators. The emission guidelines for existing units require all of the above with the exception of a siting analysis. Mercury emissions are limited to 0.55 milligrams per dry standard cubic meter (*550 micrograms per dry standard cubic meter*) or 85 percent reduction in mercury for both new and existing incinerators. Both the emission guidelines and the new source performance standards have separate emission limitations for rural hospital incinerators that are less than 200 pounds per hour requiring good combustion practice instead of add-on emission controls.

Even though a legal challenge resulted in a court remand to EPA requiring an examination of the MACT floors established for new and existing incinerators, the regulations were not vacated and were implemented by September 2002. On November 14, 2008, EPA proposed regulations addressing the remand that also satisfy the required five-year review. The final regulations were published in the Federal Register on October 6, 2009 (74 FR 51367). Mercury emission limitations for new and existing incinerators are more stringent in the new regulation than those established in 1997. However, minimal additional mercury reductions are expected to occur since the new emission limitations approximate actual performance. EPA established that their 1997 proposal would reduce medical waste mercury emissions by 95 percent and actual reductions have been determined to be almost 98 percent.

COMMERCIAL AND INDUSTRIAL WASTE INCINERATORS

The NSPS and emission guidelines promulgated in December 2000 for commercial and industrial facilities that burn non-hazardous solid waste remain in effect even though a court remand, dated July 30, 2008, relating to the definition affected sources is unresolved. At issue is whether incinerators with waste heat recovery should be covered under these requirements. Wastes materials covered include off-specification products, industrial sludges, plastic and synthetic materials, wood wastes, construction and demolition materials.

The NSPS, that became effective on December 1, 1999, requires monitoring and testing, a siting analysis, a waste management plan, establishment of control equipment operating parameters, recordkeeping and reporting, and trained and qualified operators. The emission guidelines for existing units require all of the above with the exception of a sighting analysis. The mercury emission limitation for new and existing incinerators is 0.47 milligrams per dry standard cubic meter (*470 micrograms per dry standard cubic meter*).

OTHER SOLID WASTE INCINERATORS

EPA finalized rules on December 16, 2005, that affect new and existing municipal solid waste incinerators with a capacity less than 35 tons per day and incinerators located at institutions that burn solid waste generated on site. Requirements include a siting analysis (new units only), a waste management plan, trained and qualified operators, monitoring and testing, recordkeeping and reporting. The mercury emission limitation for new and existing incinerators is 74 micrograms per dry standard cubic meter. Air curtain incinerators, except those only burning yard waste, wood waste and clean lumber, must meet all requirements in these rules.

SEWAGE SLUDGE INCINERATION

On January 22, 2007, EPA finalized their decision to exclude sewage sludge incinerators from these other solid waste incinerator regulations. Sewage sludge incinerators will be affected by requirements under Section 112 of the Clean Air Act that address area sources under the Urban Air Toxics Strategy. Sewage sludge incinerators are included in the group of area sources with a deadline of proposing regulation by April 2010 and adoption by December 2010.

HAZARDOUS WASTE COMBUSTION

Emission limitations under the Resource Recovery and Conservation Act (RCRA) have been replaced with MACT based emission limitations. However, most other RCRA requirements for hazardous waste incinerators continue to apply. New and existing hazardous waste burning incinerators, in addition to other combustors that burn hazardous waste, had MACT limitations promulgated in September 1999 that were updated in October 2005. These regulations affect major sources as well as area sources and require initial performance testing, an operating plan, operating requirements, operator training and certification, monitoring and testing, and reporting and recordkeeping.

Existing units, those in operation or that commenced construction before November 20, 1980, must meet a mercury emission limitation of 130 micrograms per dry standard cubic meter. New and reconstructed units must achieve a limit of 8.1 micrograms per dry standard cubic meter.

Table P

SUMMARY TABLE - FEDERAL MERCURY LIMITATIONS FOR WASTE INCINERATORS

Waste Incinerator Category	Waste Capacity	NSPS Applies	Mercury Emission Limitation	Comments
Large Municipal Waste Combustors	>250 TPD	September 21, 1994	50 µg/dscm[149] or 85% reduction	Identical Hg limitation for NSPS and Emission Guideline - Amended May 10, 2006 from 80 ug/dscm to 50 ug/dscm
Small Municipal Waste Combustors	35 TPD up to 250 TPD	August 31, 1999	80 µg/dscm or 85% reduction	Identical Hg limitation for NSPS and Emission Guideline
Hospital/ Medical/ Infectious Waste Incinerators	Large >500 lb/hr Medium small <200 lb/hr small rural <2,000 lb/wk	NSPS after April 6, 2010 Emission guidelines to be established in new state/federal plan	NSPS (construction after 12/1/08; modification after 4/6/10: large - 1.3 ug/dscm; medium – 3.5 ug/dscm; small – 14 ug/dscm. Emission guidelines (construction 6/20/96-12/1/08; modification 3/16/98-4/6/10): large – 18 ug/dscm; medium – 25 ug/dscm; small – 14 ug/dscm Emission guidelines (construction on or	Until applicability date for new standards, 1997 standards will apply (550 ug/dscm for all sources). Most sources are close to meeting the new standards already.

[149] Micrograms per dry standard cubic meter

Waste Incinerator Category	Waste Capacity	NSPS Applies	Mercury Emission Limitation	Comments
			before 6/20/96; modficaction on or before 3/15/98): large – 18 ug/dscm; medium – 25 ug/dscm; small – 14 ug/dscm; small rural – 5.1 ug/dscm.	
Commercial and Industrial Waste Incinerators		December 1, 1999 - units are considered existing if reconstruction or modification commences before June 1, 2001.	470 µg/dscm	Identical Hg limitation for NSPS and Emission Guideline. Under remand to resolve source definition reconsideration. Fifteen types of combustion units are exempt from these standards and guidelines.
Other Solid Waste Incinerators	Institutional incinerators burning on-site solid waste or incinerators burning <35 TPD municipal waste.	December 10, 2004 - units are considered existing if reconstruction or modification commences before June 16, 2006.	74 µg/dscm	Identical Hg limitation for NSPS and Emission Guideline.
Hazardous Waste Combustion	Area sources and major sources.		130 µg/dscm - existing 8.1 µg/dscm - new	New units are those constructed or reconstructed after November 19, 1980.
Sewage Sludge Incineration	Area source to be covered under EPA's Urban Air Toxics Strategy.			Rule promulgation is June 15, 2009. Historic NESHAPS for mercury in effect for incinerators constructed or modified after February 1, 1984.

ON-SITE SOLID WASTE INCINERATION AND OPEN BURNING

An unknown quantity of solid waste produced by households, farms and other businesses in the Great Lakes region is not introduced into any organized collection system, but rather is burned on site. This practice could be a significant source of mercury emission, given that there is no pollution control equipment and that testing at large municipal waste incinerators demonstrates that household waste incinerators that handle household waste contains mercury. Much of household waste is paper, cardboard, and plastic. Materials that have a mercury concentration are much lower than the calculated average for waste. However, the average mercury concentration can increase substantially by the occasional introduction of high-mercury items, such as older batteries, broken thermometers, fluorescent lamps, thermostats, etc. In rural areas, on-site disposal often takes the form of an outdoor "burn barrel". In urban and suburban areas, older houses and apartments were often designed with a basement incinerator, although the use of these incinerators has undoubtedly decreased in recent years.

The Minnesota Pollution Control Agency estimates that about 2% of solid waste generated in the state is burned on site, commonly in burn barrels. Assuming an average concentration of 0.5 ppm mercury in solid waste and 50% release, emissions from on-site burning in Minnesota are estimated to be 40 lb/yr.[150] The Michigan Department of Environmental Quality estimates that about 120 pounds of mercury were emitted from burn barrels in Michigan in 2002.[151] This amount represents 2% of the overall mercury emission estimate in the state of Michigan. The quantity is predicted to decline based on initiatives to reduce burn barrels, and increased education about managing mercury-containing items. The anticipated decrease in the use of mercury in products will also lead to a decrease in emissions from this source.

[150] See www.pca.state.mn.us/publications/reports/lrp-p2s-3sy07.pdf
[151] http://www.michigan.gov/documents/deq/MDEQ_MSWG_FinalReportJan2008.pdf_222256_7.pdf

5.7.3 Existing and Prospective State Regulation

MICHIGAN AIR TOXICS RULES

Under Michigan's Natural Resources and Environmental Protection Act (NREPA)[152] Michigan has adopted the standards for municipal solid waste combustors by reference.[153] Michigan also adopted the hospital/medical/infectious waste rule by reference with a stricter standard for mercury. A waste management plan is required that demonstrates that the generator of the hospital medical infectious waste has eliminated known mercury-containing materials, including fluorescent lights, from the hospital medical infectious waste stream. The mercury emissions shall also not exceed 3.0 micrograms per dry standard cubic meter or an 85 percent reduction (not exceeding 50 micrograms per dry standard cubic meter) after the 85 percent reduction.

Additionally, Michigan's air toxics rules require new or modified sources to apply the best available control technology for air toxics and the emitted toxic air contaminant must meet a health based screening concentration at the predicted maximum ambient impact. However, if an emission standard has been promulgated at the federal level under the CAA section 112(d) than the source is not covered by Michigan's air toxics rules.

MINNESOTA SOLID WASTE COMBUSTION SOURCES

Minnesota has promulgated rules to address mercury emissions from all types of solid waste combustion sources, including municipal, medical and industrial/commercial waste incinerators. Some units have mercury emission limits established through environmental review that is lower than those required by state or federal rules. Minnesota has banned the use of waste incinerators with a heat input rate of 3 mm btu/hr or smaller, except at hospitals or for the disposal of animal carcasses.

Minnesota has promulgated rules to address mercury emissions from waste combustors that generally are more stringent than federal emission guidelines and New Source Performance Standard (NSPS) Minnesota's standard for municipal waste combustors (MWC), both new and existing, is 60 µg/dscm. MWC units combusting refuse derived fuel must meet a standard of 50µg/dscm.

Hazardous waste combustors are regulated by the federal HWC NESHAP (40 CFR Part 64, Subpart EEE). Sewage sludge incinerators in Minnesota have mercury emission limits established through environmental review or through voluntary reduction actions.

NEW YORK HAZARDOUS AIR POLLUTANT REGULATION

New York State requires mercury emissions from large municipal waste combustors to be more stringent the federal NSPS of 40 CFR 60 subpart Cb for existing facilities and also the NSPS for new facilities 40 CFR 60 subpart Eb. The emission limitation for mercury from new and existing facilities is 0.028 mg/dscm (corrected to seven percent oxygen) or 85 percent removal, whichever is less stringent.

The New England States, including New York and New Jersey, all incorporated the more stringent mercury emission limit for municipal waste combustors as part of the Northeast States and the Eastern Canadian Providence's strategy to lower mercury deposition to the area.[154]

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[152]Natural Resources and Environmental Protection Act Part 55 – Air Pollution Control

[153]Natural Resources and Environmental Protection Act, R 336.1932

[154] The 1998 Mercury Action Plan of the New England Governors/Eastern Canadian Premiers includes the following recommendations.

- For municipal waste combustors: a standard of 28 micrograms per dry standard cubic meter for all large sources and for small sources where feasible.

WISCONSIN HAZARDOUS AIR POLLUTANT REGULATION

Under Wisconsin's air toxics regulations, waste incinerators are required to control emissions of hazardous air contaminants to a level that is the lowest achievable emission rate. If an incinerator is covered by regulations established under section 112 of the Clean Air Act it is not covered by the Wisconsin requirements. These requirements fill a gap, covering waste incinerators that are not covered by federal regulations.

WISCONSIN MUNICIPAL MERCURY POLLUTANT MINIMIZATION PROGRAM

Municipal wastewater treatment plants are capable of removing 95 percent of the mercury that enters their systems resulting in an effluent of about 5 nanograms per liter. The goal of the Wisconsin Municipal Mercury Pollutant Minimization Program is to achieve and maintain treatment plant effluent at or below 1.3 nanograms per liter, the Great Lakes water quality effluent criteria. The program focuses on community mercury reduction programs that reduce the use of mercury products and increase recycling for mercury products that will continue to be used. Under this program, municipalities may voluntarily achieve compliance with mercury reduction requirements prior to regulatory deadlines in exchange for flexibility and certainty in implementing mercury source reduction activities under a charter established under Wisconsin's Green Tier program. The charter focuses on mercury product elimination, or capture for recycling, from hospitals, dental offices, schools and other sectors of the community that use mercury-containing products. Fifteen Wisconsin communities are currently participating.

5.7.4 State and Federal Voluntary Programs Affecting Emissions from this Sector

Given that mercury emissions from waste incineration are driven by the mercury content of solid wastes that get incinerated, voluntary programs that help minimize the use of mercury in products or improve the management of mercury-containing wastes can help reduce mercury emissions from incinerators. For a discussion of such programs, see section 5.5 and the Mercury in Products Phase-Down Strategy.

5.7.5 Recommendations for State Action

- Recommendation 23: States should consider adopting more stringent mercury emissions limits for incineration sources, similar to those implemented by the Northeast states, including New York, as recommended under the Mercury Action Plan of the New England Governors/Eastern Canadian Premiers.
- Recommendation 24: States should implement the recommendations of the GLRC *Mercury in Products Phase-Down Strategy* in order to help reduce the amount of mercury that reaches incinerators in municipal, medical, and industrial waste, and to reduce the mercury content of sewage sludge.
- Recommendation 25: The Great Lakes states that do not have prohibitions on uncontrolled on-site waste incineration and open burning should consider banning this activity. State with bans should increase compliance efforts. Regardless of the regulatory status of on-site incineration all states should implement initiatives to divert mercury-added products for appropriate management and disposal.

- For medical waste incinerators: a standard of 55 micrograms per dry standard cubic meter, with an evaluation of the feasibility of 28 micrograms per dry standard cubic meter within three years (this lower limit was adopted).
- For sewage sludge incinerators: evaluate a standard of 100 micrograms per dry standard cubic meter.

The Committee on the Environment of The Conference of New England Governors and Eastern Canadian Premiers, 1998 Mercury Action Plan of the New England Governors/Eastern Canadian Premiers, June 1988, http://www.epa.gov/region1/eco/mercury/pdfs/Mercury_Action_Plan.pdf

6. CROSSCUTTING STRATEGIES TO ADDRESS ALL MERCURY EMISSION SOURCES

6.1 Permitting Approaches for New and Modified Sources

The eight Great Lakes states have a long history of working together to reduce mercury emissions from sources located within the Great Lakes states. In 1986, the Great Lakes states' environmental administrators entered into an agreement known as "Toxic Substances Management in the Great Lakes Basin through the Permitting Process". This Agreement required that Best Available Control Technology (BACT) be installed wherever possible on all new and existing sources of persistent air toxic pollutants which impact the Great Lakes, pursuant to implementing the Governors' "Great Lakes Toxic Substances Control Agreement." To provide consistency in the region regarding the permitting of persistent air toxics, the "Great Lakes Air Permitting Agreement" (Permitting Agreement) was signed in 1988 by representatives of the Council of Great Lakes Governors (see Appendix D. which includes Michigan's Operating Procedure document). The Permitting Agreement addresses seven primary pollutants, including mercury, identified by the International Joint Commission. In this Agreement, state permitting agencies committed to a number of actions to control emissions of these seven pollutants, including the following:

- Ensuring the installation of BACT for all new or modified sources subject to New Source Review.
- Ensuring the installation of BACT on existing sources that are required to obtain an operating permit and "considering a de minimis cutoff." Size cutoffs are identified for municipal waste incinerators, sewage sludge incinerators, and combustion of distillate oil, residual oil, and coal in Michigan's Operating Procedure document.
- For states that did not have authority to require BACT for the seven pollutants pursuing "through their appropriate regulatory process authority to implement the governors' and environmental administrators' agreements."
- Sharing permitting information with other Great Lakes states, including through the BACT/LAER Clearinghouse and Air Toxics Information Clearinghouse.

In 1990, with the amendments to the Clean Air Act, under Section 112(a) major hazardous air pollutant (HAP) sources were defined as a source that emitted 10 tons per year or more of any one HAP or 25 tons per year or more of all combined HAPs. The Clean Air Act sets this major source threshold, but allows the administrator to establish lesser quantities for a major source on the basis of the potency, persistence, potential for bioaccumulation, other characteristics of the air pollutant or other relevant factors. In the case of persistent, bioaccumulative toxic (PBT) pollutants such as mercury, concentrations in ambient air can often be relatively low, but once deposited in aquatic ecosystems the concentrations can be millions of times greater in wildlife due to bioaccumulation. Emission inventories and permit limits for PBTs are typically tracked by pounds or grams, rather than tons.

Section 112(c)(6) of the Clean Air Act requires U.S. EPA to develop emission standards accounting for 90 percent of the emissions of mercury, along with 90 percent of emissions of six other persistent bioaccumulative pollutants. Therefore, establishment of a lesser quantity cutoff could help address emissions of the remaining ten percent of the emission inventory. In addition, it could help improve the emission inventory.

Historically, states have struggled with typically poor estimates of mercury emissions, because often the sources fall below the major threshold category and would not be subject to a standard, or they would have no need to demonstrate a standard doesn't apply to them.

Accurate emissions inventories are the foundation for assessing mercury impacts, and for good policy decisions. As states and EPA implement each mercury control standard, a more accurate mercury emissions estimate for that source results. In nearly every instance, states learn that previous emission estimates were not accurate.

Sources affected by state and/or federal rules do a much better job of determining their potential and actual emissions, and the emission estimates improve substantially.

If a lower threshold was established for PBTs, this would require sources to improve emission estimates, most frequently to demonstrate that the threshold has not been exceeded. Additionally, there would be an incentive to control those emissions to stay well below that threshold and would result in reduced emissions. A federal threshold is likely most effective because it ensures a level playing field for industries. The threshold for this subset of HAPs should be considerably lower due to the persistence, bioaccumulative nature and known toxicity. Based on current state programs the threshold for establishing major sources could range from 3 to 25 pounds for mercury emissions.

During the 1990s, the Great Lakes states implemented the agreement to various degrees and exchanged information on applicable air permits. Since then some states have implemented their own state-only air toxic regulations which typically superseded the historical permitting agreement and which reduced the size cutoffs for sources that emit persistent bioaccumulative toxic air pollutants.

AIR PERMITTING PROGRAM OVERVIEW

Illinois incorporates all federal National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations under Section 9.1 of the Illinois Environmental Protection Act. Mercury limits for any source category covered by a NESHAP as well as any New Source Performance Standard (NSPS) and any Emission Guidelines (e.g., incinerators) are also included in this section of the Act. Therefore, any mercury limits promulgated in these federal regulations are then incorporated into Illinois permits. The vacated Boiler NESHAP (40 CFR 63 Subpart DDDDD-Industrial Commercial Institutional Boilers and Process Heaters) now warrants case-by-case MACT determinations in Illinois.

Illinois has mercury requirements for hospital medical infectious waste incinerators of 0.55 mg/dscm or 0.24 grains per thousand dscf or 85% reduction for small, medium and large incinerators per 35 Ill. Adm. Code 229.125(b). Rural incinerators were required to meet 7.5 mg/dscm or 3.3 grains per thousand dscf per 35 Ill. Adm. Code 229.126(b). At this time, all hospital medical infectious waste incinerators were required to shutdown per a memorandum by the Governor of Illinois.

Illinois may also add mercury requirements to permits as a criteria pollutant. For example, PM emission limits at sources that include Hg emissions are limited to nominal mercury emission rates of 0.1 lb/hr and 0.44 tons/year (880 pounds/year).

Illinois' mercury rule for large coal-fired electrical generating units (35 IAC Part 225) requires mercury reductions from coal-fired power plants in two phases. Phase I that went into effect July 1, 2009, requires that coal-fired power plants comply with either an output based emission standard of 0.0080 lbs mercury/gigawatt hour (GWh) or a minimum 90% reduction of input mercury, both on a rolling 12-month basis. Plants with the same owner or operator may comply with the limit on a systems-wide basis by averaging across their entire fleet of plants in Illinois, provided that each plant meets a minimum output based emission standard of 0.020 lbs mercury/GWh or a minimum 75% reduction of input mercury. Phase II begins January 1, 2013, and requires plants to comply with either an output based emission rate or a mercury reduction efficiency as in Phase I. In this phase plant-wide averaging can be used to demonstrate compliance with the limit.

There are two provisions in the rule that allow companies to extend the compliance deadlines to 2015. The first is a temporary technology based standard that provides relief for a limited number of emission units that install appropriate mercury controls but are unable to achieve compliance. Eligible units are only required to operate the mercury controls in an optimal manner to be deemed in compliance. This provision can be used by up to

25% of a company's generating capacity. The second provision allows sources to voluntarily comply with a multi-pollutant standards approach. Sources can commit to voluntarily meeting numerical emission standards for both NO_x and SO_2 and in return are provided additional flexibility in complying with the mercury emission standards. Companies are still required to install mercury controls able to achieve a 90% reduction on all but a few of the smallest units but actual compliance is not required until 2015 provided the mercury controls are operated in an optimal manner. There is another provision similar to the multi-pollutant standards approach called the combined pollutant standards approach where units are required to meet the same type of requirements or shut down their units by a certain date.

Indiana addresses mercury emissions through its permitting and compliance programs. Indiana's construction permitting rule (326 IAC 2) establishes a significant permit level for potential emissions of mercury at 0.1 ton per year (200 lbs/year) for major sources. New sources or modifications to existing sources emission units with potential emissions that exceed this level would need to limit mercury emissions to below this level or be subject to Best Available Control Technology (BACT) review. The BACT review requires a review of BACT and an air quality analysis. New or modified source impacts are established at 0.25 $\mu g/m^3$ with a 24 hour averaging time. The state does not have legal authority to conduct multi pathway risk assessments as part of the air permitting process. Source specific mercury emissions limits included in state and federal rules, NSPS, and NESHAPs, are also implemented through the air permitting and compliance programs. The state has delegation of MACT standards for major sources and some non major sources, and has the ability to go beyond MACT limits in permits at MACT sources. Stack testing may be required in some cases.

Michigan utilizes its air quality regulatory programs to reduce mercury released from point sources through the air permitting process.[155] In 1994, the AQD implemented the air toxics rules to address the release of toxic air pollutants.[156] Any new or modified source of mercury emissions must go through a best available control technology (BACT) for toxics review (commonly called T-BACT); these rules do not apply to existing sources. Additionally, if a federal MACT is required for a source sector, T-BACT is not required.

New or modified sources are required to demonstrate the maximum degree of mercury emission reduction reasonably achievable taking into account energy, environmental, economic impacts, and other costs. New or modified sources of mercury emissions must also go through a health-based screening review that uses modeling of source emissions to predict the ambient impact of a toxic chemical. Predicted ambient impacts can be no greater than health-based screening levels. Typically, these screening levels only consider exposure from direct inhalation.

Because the primary concern for mercury is from indirect exposure pathways (i.e., consumption of fish), the health-based inhalation screening level of 0.3 $\mu g/m^3$ (with a 24-hour averaging time) was withdrawn and emissions of mercury are evaluated on a case-by-case basis. Rule 229 2(b) allows the development of an alternative methodology to assess noncarcinogenic health effects that can be demonstrated based on more appropriate toxicologic grounds and supported by scientific data. There is overwhelming support in the published literature documenting the risk of exposure to mercury beyond inhalation exposure only, due to its persistence and bioaccumlative properties in the environment.

Therefore, mercury emission limits for new and modified sources are set on a case-by-case basis, considering not only the magnitude of emissions but also the proximity of inland lakes to the source. For some sources, multipathway risk assessments (MPRAs) are conducted to account for the non-inhalation pathways of exposure associated with air contaminants. MDEQ utilizes the Mercury Risk Estimation Method (MMREM) developed

[155] AQD permitting guidance at http://www.deq.state.mi.us/documents/deq-ess-caap-airpermittechmanual-Tab16.PDF

[156] More on Michigan's Air Toxic Regulations are available at http://www.deq.state.mi.us/documents/deq-esscaap-airpermittechmanual-Tab06.PDF

by MPCA as a screening tool when conducting MPRAs.[157] MMREM is based on the proportionality principle, which accounts for the background level of mercury in sport fish and the associated background mercury deposition rate. The model calculates an estimated increase in fish mercury based on a proportionate increase in the deposition attributable to the additional source of interest. The MMREM is similar to the U.S. EPA Mercury Maps model because it is based on the proportionality principle.[158].

Finally, because mercury is of concern beyond just inhalation exposure, Michigan currently has no exemptions for mercury sources and requires review for any size source that emits mercury. Therefore, new or modified mercury sources cannot receive an exemption from a permit to install under mercury emissions do not qualify for an exemption from a permit to install under MDEQ's AQD Rule 290 (Natural Resources and Environmental Protection Act, 1994 PA 451) and therefore case-by-case reviews are conducted.

Minnesota utilizes various approaches to reduce mercury air emissions through air permitting. State rules establish a standard of performance for waste combustors (municipal waste and medical waste) resulting in a mercury emission limit that is incorporated into facilities' permits.[159]

Reductions at the state's three largest EGU emission sources called for in 2006 state legislation are being incorporated into facility permits. For nearly all other existing sources (except mercury recyclers, mercury product manufacturers and crematories) proposed rules will require development of reduction plans to meet 70-90 percent reductions by 2018 or 2025. These plans will be incorporated into each facility's permit. Goals and timeframes were recommended by stakeholders and can be found at: http://www.pca.state.mn.us/air/mercury-reductionplan.html

Recent, new, or expanded sources of mercury emissions have also had mercury emissions limits and reduction plans set through the environmental review process on a case-by-case basis. New sources are required to go through a health-based screening review that uses modeling of source emissions to predict the ambient impact mercury and other substances. Because the primary concern for mercury is from indirect exposure pathways (i.e., consumption of fish), the health-based inhalation screening level of 0.3 $\mu g/m^3$ (with a 24-hour averaging time) was withdrawn and emissions of mercury are evaluated on a case-by-case basis. This evaluation considers not only the magnitude of emissions but also the proximity of inland lakes to the source.

For some sources, multi-pathway risk assessments (MPRAs) are conducted to account for the non-inhalation pathways of exposure associated with air contaminants. MPCA utilizes the Mercury Risk Estimation Method (MMREM) as a screening tool when conducting MPRAs. MMREM, developed by the MPCA in 2006, is based on the proportionality principle, which accounts for the existing (background) level of mercury in sport fish and the associated background mercury deposition rate.

Future, new, and expanding sources greater than 3 lb will be required to utilize best controls and offset added emissions by arranging for equivalent reductions from existing sources in the state. This requirement may be incorporated into air permits.

Additionally, Minnesota's strict waste regulations also help to reduce the release of mercury into the atmosphere. Minnesota's waste regulations include a disposal ban of mercury-containing items into solid waste or wastewater systems along with specific goals for mercury release reductions, progress reports, and

[157] Minnesota Pollution Control Agency (MPCA). 2006. MPCA Mercury Risk Estimation Method (MMREM) for the Fish Consumption Pathway. Version 1.0.

[158] U.S. EPA. 2001. Mercury Maps. A Quantitative Spatial Link Between Air Deposition and Fish Tissue. Peer Reviewed Final Report. Office of Water. EPA-823-R-01-009.

[159] http://www.pca.state.mn.us/air/rulechange-combustor.html

fluorescent light recycling facility permit requirements and mandatory fluorescent lamp collection programs by public utilities.[160]

New York regulates mercury through two sector specific regulations and one that covers all emissions of toxic pollutants. 6 NYCRR subpart 219-7 regulates mercury emissions from large municipal waste combustors and is described in the Waste Incineration section of this report. 6 NYCRR Part 246 regulates mercury from coal-fired electricity generating units as described in the Fossil Fuel Electric Power Generation section of this report. All other processes that emit mercury are covered under 6 NYCRR Part 212.

The General Process Emission Source regulation 6 NYCRR Part 212, written in 1970, is the gateway regulation for the review of all toxic air contaminants. NYSDEC's air pollution control engineers are responsible for assigning an Environmental Rating for each air contaminant from all process sources. Based upon the potential environmental effects of an air contaminant when released to the environment, the air contaminant is assigned a rating of "A", "B", "C", or "D".

If a specific process source regulation was enacted after Part 212 was promulgated, such as Portland cement manufacturing or gasoline terminals, etc., these sources were exempted from Part 212. Exemptions are category-specific unless an air contaminant emitted at a particular facility, in the exempted source category, has an environmental impact meeting the definition of an "A" Environmental Rating. An air contaminant meeting the following definition is given an Environmental Rating of "A":

> "an air contaminant whose discharge results, or may result, in serious adverse effects on receptors or the environment. These effects may be of a health, economic or aesthetic nature or any combination of these." 212.9(a)

Part 212.9(a) lists the criteria to determine an environmental rating, these include the contaminant's toxicity, predicted modeled ambient impacts, proximity of ambient impacts to neighboring communities, existing background ambient concentrations and potential future growth of the impacted area. Part 212.9(b) Table 2 shows the degree of air cleaning required for individual compounds rated A through D based upon its Emission Rate Potential (potential to emit).

Depending upon the air contaminant's toxicity, contaminants are classified as High, Moderate or Low toxicity through the guidance document DAR-1. Appendix A of DAR-1 assists Regional staff on determining an initial Environmental Rating. Section A. II states that initially contaminants meeting the definition of High, Moderate, and Low should be rated "A", "B", and "C" respectively. This initial rating should then be modified based upon the additional criteria listed in 212.9(a) Table 1 to determine the final environmental rating.

Elemental mercury and all mercury compounds were classified as High toxicity air contaminants in the 2000 DAR-1 AGC/SGC (Annual Guideline Concentrations/Short-term Guideline Concentrations) Tables that were released to the public on July 12, 2000. Mercury's designation as a High toxicity air contaminant was based upon scientific information indicating that mercury is a toxic metal that persists and cycles through the environment as a result of natural and human activities. Whereas its ambient concentration could be relatively low, its ability to be deposit in water bodies and bioconcentrate in the food chain makes mercury an air contaminant with serious adverse effects on receptors or the environment. The Air Toxic Section of the Division of Air Resources recommends that the emissions of mercury and mercury species be assigned an Environmental Rating of "A".

[160]Minnesota's Waste Management Act can be found at http://www.moea.state.mn.us/publications/wma-mercury.pdf.

As a result of mercury's Environmental Rating of "A", Part 212.9 requires those sources with a mercury emission rate potential greater than 1 pound per hour to reduce emissions by 99 percent or greater, or install Best Available Control Technology. As written in Part 212, those sources with an emission rate potential less than 1 pound per hour are subject to a degree of air cleaning which shall be specified by the commissioner. Guidance for air contaminants whose primary health effect is from inhalation need to meet the ambient health-based guideline concentrations established in the Department's AGC/SGC (Annual Guideline Concentrations/Short-term Guideline Concentrations) Tables. For mercury compounds, meeting the AGC alone is not appropriate because deposition to water bodies and the bioaccumulation in fish is the pathway of exposure for humans and animals. To determine compliance with Part 212 when the emissions of mercury from a process source are less than 1 pound per hour, New York State DEC recommends that the emissions of mercury be kept to a minimum using a BACT approach.

Ohio EPA Division of Air Pollution Control (OEPA DAPC) administers a permit to install and operate program that requires emission limitations for all types of pollutants including mercury. OEPA DAPC has regulated mercury emissions through implementation of best available technology requirements in accordance with OAC chapter 3745-31 and air toxic requirements in accordance with OAC rule 3745-114-01. OEPA DAPC has been given delegation of authority to administer and enforce the federal regulations promulgated under 40 CFR Part 60 (New Source Performance Standards), 40 CFR Part 61 (National Emission Standards for Hazardous Air Pollutants) and 40 CFR Part 63 (National Emission Standards for Hazardous Air Pollutants for Source Categories). A number of the subparts under these federal rules contain emission limitations for mercury. OEPA also has delegation of authority to issue permits under Title IV (40 CFR Part 72) of the 1990 Clean Air Act that may contain provisions for monitoring and record keeping of mercury emissions and Title V (40 CFR Part 70) of the 1990 Clean Air Act that may contain mercury emission limitations in accordance with Maximum Achievable Control Technology (MACT) standards. More information on these federal regulations can be found at http://ecfr.gpoaccess.gov .

OEPA DAPC has issued a number of air permits with mercury emission limitations and monitoring, record keeping, reporting and testing requirements. Mercury control requirements are included in some of these permits. See the footnote for examples.[161]

[161] New Steel International, Inc.: Facility ID 0773000215; PTI 07-00587 issued final on May 6, 2008; http://www.epa.state.oh.us/dapc/pti_issued/pti_pdf_08/0700587f.pdf

FDS Coke Plant: Facility ID 0448020084; PTI 04-01360 issued final on January 31, 2008; http://www.epa.state.oh.us/dapc/pti_issued/pti_pdf_08/0401360fm2.pdf

Mahoning Renewable Energy: Facility ID 0250001120; PTI 02-23003 issued final on April 3, 2009; http://www.epa.state.oh.us/dapc/permits_issued (scroll down to 262448)

Spring Grove Resource Recovery, Inc.: Facility ID 1431072600; PTIO P0098558 issued final on December 8, 2008; http://www.epa.state.oh.us/dapc/permits_issued (scroll down to 226750)

PSC Metals, Inc.: Facility ID 1576000113; PTI 15-01708 issued final on May 20, 2008; http://www.epa.state.oh.us/dapc/pti_issued/pti_pdf_08/1501708m1.pdf

AMP Ohio: Facility ID 0653000069; PTI 06-08138 issued final on February 7, 2008; http://www.epa.state.oh.us/dapc/pti_issued/pti_pdf_08/0608138f.pdf

Haverhill North Coke Company: Facility ID 0773000182; PTI 07-00511 issued final on November 10, 2008; http://www.epa.state.oh.us/dapc/permits_issued (scroll down to 220311)

On August 3, 2006, Ohio statues were revised to incorporate into law Ohio EPA's "Air Toxics Policy," often referred to as "Option A." Under this provision, permits to install are required for new and modified sources of air contaminants. For sources that are not subject to a federal MACT standard or residual risk standard, permit applications must include information sufficient information to allow a modeling determination of whether emissions from the new or modified source would result in an exceedance of Ohio's Maximum Acceptable Ground Level Concentrations (MAGLC) for air contaminants. Ohio EPA can prevent construction of new sources that would result in an exceedance of a MAGLC, and for sources that would result in a maximum ground level concentration higher than 80 percent of the MAGLC, Ohio EPA can include allowable daily emissions limits in the permit to ensure that actual emissions are no higher than the level modeled. For sources that would result in maximum ground level concentrations less than 80 percent of the MAGLC, Ohio EPA can include permit conditions that require reporting on whether actual source operations are consistent with the information used to conduct the permit modeling. The newly amended statute also requires Ohio EPA to promulgate a list of toxic air contaminants that would fall under this review requirement. On December 01, 2006, Ohio EPA's list of toxic air contaminants, including mercury, became effective[162].

Pennsylvania implements a case-by-case best available technology (BAT) review for permit applications for new sources and permit applications to modify existing sources. Sources subject to permitting requirements which could be expected to release mercury, i.e. waste coal burning electric generating facilities waste incinerators would include mercury limits and controls, where appropriate.

Pennsylvania has attempted to go beyond federal rule by developing and promulgating a rule to reduce mercury emissions from coal fired electric generating units. However, this rule has been vacated by the Commonwealth Court. That ruling is currently under appeal with Pennsylvania State Supreme Court. Nevertheless, since Pennsylvania incorporates all federal MACT regulations by reference, in Title 25 chapter 124 of the PA Code, all new EGUs will be required to undergo a 112(g) case-by-case analysis. Accordingly, any mercury limit for any source category covered by a NESHAP is incorporated by reference in the PA code. This holds true for New Source Performance Standards and Emission Guidelines as well since they are incorporated by reference in the PA Code in Title 25 Chapter 122. These NESHAP and NSPS requirements would be in addition to Pennsylvania state BAT requirements.

Also, for certain source categories Pennsylvania has state permitting limits for mercury. These source categories include municipal waste incinerators, hazardous waste incinerators, and sewage sludge incineration. Air Quality has a general permitting program in Pennsylvania. The general permit number 24 which covers Pharmaceuticals and Specialty Chemical Production contains special conditions for mercury emissions. Pennsylvania has no exemptions for mercury sources and requires review for any size source that emits mercury.

Wisconsin regulates mercury air emissions primarily by the state NR446 rule. The emissions limits are as follows.
NR 446.03 Mercury emission limits:
(1) No person may cause, allow or permit emissions of mercury in such quantity and duration as to cause the ambient air concentration to exceed 1 mg/m^3, averaged over a 30−day period.
(2) (a) No person may commence construction or modification of a stationary source that results in an increase in annual allowable emissions of mercury of 10 pounds or more from the new or modified source unless the person has obtained a permit under ch. NR 406. The Wisconsin DNR may not issue a permit under ch. NR 406 for the source unless the Department finds that emissions of mercury will be controlled to a level which is best available control technology or BACT.

[162] See Ohio Revised Code 3704.03(F) and Ohio Administrative Code 3745-114-01.

Additionally, Wisconsin's rules require facilities to report mercury emissions (and pay a fee) for their emissions if their annual emissions exceed 2.35 lbs/year for alkyl mercury compounds, 4.71 lbs/year for aryl mercury compounds and 5.88 lbs/year for inorganic mercury. If there are changes of over 10 lbs/year increase in mercury emissions, then the facility would require BACT (for existing facilities) Therefore, the existing smaller sources that emit mercury are generally not regulated in Wisconsin.

Summary

Based on the information summarized for each of the Great Lakes states several important points stand out based on this information. There is a wide variation of the size cut offs or exemptions allowed in each state regarding the amount of mercury allowed to be emitted into the atmosphere. The range is from 1 pound up to hundreds of pounds that would be allowed to be emitted into the atmosphere without any reporting or air permit required. Five out of the eight Great Lakes states require additional review for mercury, beyond the co-benefit controls that can occur based on controlling criteria pollutants.

Recommendations

- Recommendation 26: All states should require Best Available Control Technology (BACT) for mercury emissions from new and modified air sources. States that do not currently have the authority to require BACT for new and modified air sources should consider legal changes that would provide such authority, considering a threshold of 10 pounds or less of mercury per year.

- Recommendation 27: The Great Lakes states recommend that EPA use the existing authority in Section 112(a) of the Clean Air Act to establish a major source category threshold for mercury that is a lesser quantity, appropriately reflecting the quantities in which mercury is actually released, and its potency, persistence and potential for bioaccumulation.

- Recommendation 28: States should consider mandatory reporting for new and existing sources that emit mercury (considering a threshold of 5 pounds per year or less).

- Recommendation 29: States should consider adopting policies that would allow multipathway risk assessments to be conducted as part of the construction permit process.

- Recommendation 30: States should contribute BACT data on mercury emissions controls to the national RACT/BACT/LAER Clearinghouse (RBLC) in order to make it into an effective resource for information on mercury controls, in addition to the existing information that it provides on criteria air pollutants. (http://cfpub.epa.gov/rblc/htm/bl02.cfm).

6.2 Total Maximum Daily Load (TMDL) Implementation Plans

Section 303(d) of the federal Clean Water Act requires states to identify water bodies that do not meet applicable water quality standards and establish Total Maximum Daily Loads (TMDLs) for such waters. The standards are set on a wide range of pollutants, including bacteria, nutrients, turbidity, including mercury. A water body is "impaired" if it fails to meet one or more water quality standards. These standards define how much of a pollutant can be in the water and still allow it to meet designated uses such as swimming and fishing.

Water bodies that do not meet water-quality standards or do not fully support beneficial uses are added to a listing of water bodies referred to as an Impaired Waters List. Mercury, usually as a contaminant in fish, has caused thousands of lakes and rivers in the great lakes region to be classified as impaired. In Minnesota, 1,234 (check) or two thirds of assessed water bodies are considered impaired due to mercury.

To begin to address impaired waters, states are required to evaluate the sources of pollution, the reduction in the pollutant needed to meet water-quality standards, and allowable levels of future pollution. This evaluation is called a Total Maximum Daily Load, or TMDL and must be approved by the EPA. EPA has approved over 150 mercury TMDLs, mostly for specific water bodies or watersheds. Although TMDLs are intended to reduce water pollution, states have also employed statewide or regional TMDLs to identify the mercury loadings that result from mercury air emissions since a large share of the mercury pollution in lakes and rivers is due to atmospheric deposition.

States in the Northeastern US and the state of Minnesota have prepared TMDLs for Mercury. The Northeast Regional TMDL covers the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont and was developed in cooperation with the New England Interstate Water Pollution Control Commission (NEIWPCC). Throughout the Northeast, elevated levels of mercury in certain fish species have resulted in fish consumption advisories in every state covering more than 10,000 lakes, ponds, and reservoirs and over 46,000 miles of rivers.[163]

Both of these recent TMDLs have concluded that substantial reductions in atmospherically-transported air emissions of mercury are needed in order to meet water quality standards. Since most of the mercury depositing in the states originates from outside of the state or region, reductions are needed from all sources that contribute to deposition, not just sources within the states in question. The Northeast Regional TMDL concluded that a 98 percent reduction was needed from 1998 levels; the Minnesota TMDL seeks a 93 percent reduction from 1990 levels. By applying the reduction goals to instate emissions, Minnesota's TMDL established a final air emission goal of 789 lb/year, compared to approximately 3400 lb in 2005. In the case of the northeast states, the report *Northeast States Succeed in Reducing Mercury in the Environment* highlights effective programs that are resulting in tangible and positive improvements in reducing mercury in the environment. The TMDL goes further and calls for a 98 percent reduction in anthropogenic mercury sources from both sources within the Northeast states and sources outside the region. Because the majority of mercury in the region originates from out-of-region sources, the Northeast states are asking for more stringent federal controls on mercury emissions.

Once a TMDL is approved by the EPA, states are responsible for implementing measures to achieve the goals established in the TMDL. In Minnesota, the MPCA worked with stakeholders to develop sector and source-specific reduction strategies as well as interim and final timeframes for meeting the goals. The year 2025 was selected as the final implantation date. With successful implementation, mercury emissions will decline 93 percent between 1990 and 2025. A copy of Minnesota's implementation plan, detailing the strategies and reduction targets by sector, can be found at www.state.mn.us/mercury. Reductions called for in a TMDL from water point sources are legally required. However, since air deposited mercury is considered a non-point source in a TMDL, air reductions called for in the implementation plan are not enforceable on their own. In Minnesota's case, existing air program authority will be used to compel air reductions.

A less detailed implementation plan was prepared in the Northeast Regional TMDL describing reductions in three phases. This plan takes into account the significant reductions already made by the Northeast states and the need for updated emissions inventory and deposition modeling at the end of the second phase in 2010. An appropriate implementation plan based on that updated information will be developed for the third phase. Because the Northeast states are already addressing all mercury sources within their control, additional controls are not expected of in-region sources as part of the implementation for Phases I and II. As in the case of the

[163] Northeast Regional Mercury Total Maximum Daily Load report and Northeast States Succeed in Reducing Mercury in the Environment, October 2007

Minnesota TMDL, greater reductions are needed from out-of-region sources in order for the TMDL to be fully implemented.

To completely address out-of-state reductions in the United States, NEIWPPC chose to file a petition with the EPA under a provision of the Clean Water Act known formally as CWA Section 319(g)(1) or 33 U.S. Code Section 1329(g)(1). It states: *"If any portion of the navigable waters in any State which is implementing a management program approved under this section is not meeting applicable water quality standards or the goals and requirements of this chapter as a result, in whole or in part, of pollution from nonpoint sources in another State, such State may petition the [U.S. EPA] Administrator to convene, and the Administrator shall convene, a management conference of all States which contribute significant pollution resulting from nonpoint sources to such portion."* The conference's purpose *"shall be to develop an agreement among such States to reduce the level of pollution"* and improve the water quality in the affected areas.

According to NEIWPCC, data show that approximately 70 percent of mercury deposited in NEIWPCC's member states actually comes from sources outside of the United States. However, just under half of the roughly 30 percent that comes from U.S. sources comes from sources outside the NEIWPCC states. The out-of-region states with the most significant contributions are Pennsylvania (21.7 percent of deposition in NEIWPCC states attributable to out-of-region U.S. sources), New Jersey (5.6 percent), Ohio (5.5 percent), West Virginia (3.9 percent), Maryland (3.7 percent), Michigan (2 percent), Virginia (1.5 percent), Indiana (1.3 percent), Kentucky (1.2 percent), North Carolina (1.1 percent), and Illinois (0.9 percent). While both in-region and out-of-region states have made changes to their mercury reduction programs since the REMSAD data were collected, the changes are not substantial enough to alter the main conclusion: a significant portion of the mercury deposited in the Northeast originates with sources in the states identified in the NESCAUM study. In fact, a key goal of the requested conference will be to ascertain the adequacy of both in-region and out-of-region mercury reduction programs and initiatives in meeting Clean Water Act requirements for mercury impairments in the Northeast.

NEWIPCC is awaiting a response to their petition. For more information on sources of loading and estimated load reductions needed to reduce impairments in the northeastern states, please refer to www.neiwpcc.org.

6.3 Stakeholder Involvement

Developing and implementing approaches to reduce mercury releases can be successfully accomplished through working with stakeholders, involving a variety of interests and viewpoints. Stakeholder participation processes have been used to develop programs, regulations and comprehensive reductions strategies. Examples related to mercury:

- Michigan Mercury P2 Task Force
- National Vehicle Switch Recovery Efforts
- Minnesota Mercury Strategy Work Group

Michigan Mercury P2 Task Force

In 1994, Michigan convened the Michigan Mercury Pollution Prevention Task Force (M2P2) to develop recommendations to reduce mercury releases. The M2P2 Task was comprised of representation from industry, trade associations, environmental, government, and academic groups focusing upon seven sectors which included general public, healthcare, dental, automotive, electrical users/manufacturers, chemical users/manufacturers, and utilities. Through their monthly deliberations and with sub-group support, a final report was developed containing over seventy (70) consensual pollution prevention (P2) recommendations.

The M2P2 Task Force's Final Report was released in 1996 and was given to the Michigan DEQ for implementation. DEQ's Environmental Assistance Division (EAD), prepared a draft Implementation Strategy for the Final Report, listing lead entities and anticipated time requirements for implementation for each of the seventy recommendations. In February 1997 MDEQ's Director officially endorsed the M2P2 Final Plan Implementation Strategy and directed DEQ staff to undertake the identified actions to accomplish the recommendations of the Final Report, within budgetary and resource constraints.

Progress information has been condensed, summarized, and is available by downloading the M2P2 Final Progress Report at http://www.deq.state.mi.us/documents/deq-ead-p2-mercury-mercprog.pdf.

National Vehicle Switch Recovery Efforts

Until 2003, many motor vehicles contained mercury switches to activate lighting in trunks, hood and glove compartments as well as a component in anti-lock brakes or ride control systems. To reduce end-of-life release of mercury, state and local jurisdictions, as well as recycling industry representatives established a variety of voluntary and regulatory programs attempting to capture these switches before the recycling of the vehicle.

States, environmental groups, the EPA, vehicle manufacturers and the steel recycling industry participated in a stakeholder dialogue the resulted in collaborated to establish the National Vehicle Mercury Switch Recovery Program or NVMSRP. The NVMSRP, formed by a memorandum of agreement in 2006, is intended to harmonize state and local requirements and implement a collaborative voluntary program intended to capture at least 80 percent of vehicle mercury switches, in conjunction with existing state programs. More information on this program can be found on EPA's web site at; http://www.epa.gov/mercury/switch.htm.

Minnesota Mercury Strategy Work Group

In 2007, to develop strategies to implement the air reduction goals established in Minnesota's Statewide TMDL for Mercury (described in Section 6.2), the MPCA convened a group of stakeholders and retained a neutral facilitator to manage the process. A group of 17 stakeholders met 1-2 times per month for a year and identified sector and source-specific reduction strategies to reduce in-state emission sources by about 86 percent by 2025. The group, referred to as the Strategy Work Group, consisted of representatives from industry, environmental advocacy groups, state and local government and others. A larger group of about 50 additional stakeholders was consulted several times to affirm the Strategy Work Group's work. Details about the process can be found at http://www.pca.state.mn.us/publications/wq-iw1-20.pdf.

In general, stakeholder processes have these benefits:

- Develop shared ownership and support for solutions among participants
- Increase creativity in addressing the issue at hand
- Influence stakeholders to do their part if they see others stepping up
- Increased stakeholder trust in the custodial department's ability to manage the process effectively
- Increase stakeholder understanding of the issue
- Improve departmental decision-making by incorporating stakeholder advice and knowledge into the design and management of the program, regulation or strategy
- Avoid conflicts by identifying and addressing critical stakeholder issues early in the process
- Develop mutual understanding and improve stakeholder relationships thus enhancing the success of sustained implementation

Stakeholder processes can have these disadvantages:

- Can be lengthy and typically require a significant time commitment
- The outcome is unpredictable and may alter from expectations, perhaps less ambitious than expected
- May require an outside facilitator

6.4 Voluntary Programs

Significant improvements in environmental performance, including mercury emissions reduction, can take place even in the absence of regulatory requirements. Technological changes motivated by economic considerations, including production efficiency, energy efficiency, reduced costs of material inputs, and worker safety, can yield major environmental benefits, even if they were not undertaken for environmental reasons. Moreover, industry leaders sometimes choose to implement environmental improvements voluntarily in order to be good citizens, to gain good publicity, to avoid regulatory attention, or to find cost-effective means of compliance with anticipated future regulation. Furthermore, ordinary citizens frequently engage in voluntary pollution reduction efforts, in their purchasing and disposal choices.

This section focuses on actions that governments can take to help motivate voluntary efforts to reduce mercury releases. There are several ways that government programs can promote voluntary efforts, including: raising awareness of an environmental problem and the potential solutions to that problem; publicly challenging industry to take action; supporting research into control technologies and approaches; subsidizing environmentally-preferable choices, and making less preferable choices more expensive. Below, we discuss just a few of the many voluntary mercury reduction programs that contain elements of these approaches.

Mercury Awareness Programs for the General Public

All of the Great Lakes states began working in various ways in the 1990s to promote public awareness of mercury. For instance, Indiana DEM developed a formal "Mercury Awareness Program" that included explanations of the mercury problem, descriptions of the household products that might contain mercury, and information about where these products could be recycled. These materials were presented in the IDEM website, at public events such as the state fair, and in inserts to utility bills. Along with promoting awareness, Indiana DEM took specific steps to reduce the costs of environmentally-preferable behavior (mercury product recycling), by providing free household hazardous waste recycling at facilities in all 92 counties. As a result of these efforts, IDEM has collected 53 tons of mercury and mercury-containing items and debris from households and small businesses in 2007.[164] Increased public awareness of mercury, combined with convenient mercury collection through household hazardous waste programs, has resulted in significant mercury collections in all of the Great Lakes states.

Binational Toxics Strategy Mercury Reduction Challenge

In 2007, the U.S. EPA and Environment Canada signed the Great Lakes Binational Toxics Strategy, which included a "challenge" to industry to help achieve reductions of 50 percent in mercury use and mercury emissions nationwide. In response to this challenge, the Chlorine Institute committed to a 50 percent reduction in mercury use by 2005 on behalf of the U.S. mercury cell chlor-alkali industry. Mercury use actually declined 91 percent on a capacity-adjusted basis between 1995 and 2005 with a decline of 94 percent when plant shutdowns and conversions are included. These voluntary efforts included a number of actions that reduced mercury emissions (see section 5.3). The American Hospital Association also responded to the Binational Toxics Strategy challenge by agreeing to virtually eliminate mercury from hospital waste by 2005.

Auto Mercury Switch Use and Disposal

The Michigan Department of Environmental Quality began to work with the auto industry to examine mercury usage in 1991, with the Auto Pollution Prevention Project. In 1994, this effort continued with an automobile

[164] http://www.in.gov/recycle/files/2008_hhw_annual_report.pdf

subgroup of the Michigan Mercury Pollution Prevention (M2P2) Task Force. Other subgroups of this voluntary effort focused on general public, health care, dental, electrical manufacturers/users and chemical manufacturers/users. Stakeholders in each group were asked to work cooperatively to identify opportunities for mercury pollution prevention. The M2P2 auto subgroup identified automotive use of mercury switches as an important issue, and the auto industry voluntarily committed to phase out mercury switches, where feasible, beginning with the 1997 and 1998 model years.[165] The last auto mercury switches were used model year 2002 vehicles, and a 2007 federal regulation prevents renewed use of mercury in vehicle switches.[166]

Numerous states developed voluntary programs to promote removal of mercury switches from end-of-life vehicles. Some of these programs utilized the regulatory leverage of actual or potential limits on mercury releases in air permits for auto shredders (New York DEC) or in storm water discharge permits for auto recyclers (Wisconsin DNR) to promote voluntary participation. Other programs utilized incentive payments to auto recyclers for every switch removed, provided voluntarily by a steel manufacturer (Minnesota PCA) or provided as required in law by auto manufacturers (Maine DEP, Illinois EPA). A national voluntary switch removal effort was created by the National Vehicle Mercury Switch Recovery Program in 2006, with the participation of the federal government, states, the auto and steel industries, auto recyclers, and environmental groups. This voluntary program subsequently became a mechanism for compliance with regulatory requirements for steel production facilities (see section 5.4.2).

Nevada Gold Mine Voluntary Mercury Air Emission Reduction Program

The Toxics Release Inventory (TRI) report for 1998 (released in 2000) revealed that gold mines in Nevada, which had not been previously required to report emissions to TRI, were a major source of mercury emissions. Four large mines reported 13,560 pounds collectively of atmospheric mercury emissions, making these facilities the largest individual mercury sources in the nation and making gold mining one of the largest emissions sectors. After this information became public, the Nevada Department of Environmental Protection and U.S. EPA worked with the Nevada mines to develop a Voluntary Mercury Air Emission Reduction Program (VMRP), which established a goal of reducing mercury emission 33 percent by 2003 and 50 percent by 2005. The program actually achieved 40 percent reduction by the end of 2002 and a 75 percent reduction by the end of 2003.[167] This voluntary program formed the basis for a regulatory program subsequently developed by Nevada DEP. The regulatory program improved on the voluntary program by extending mercury emissions control to all Nevada gold mines (not just the four that participated in the VMRP), by establishing specific data collection and reporting requirements, by ensuring continued operation of controls at maximum efficiency, and by establishing MACT for all mercury-emitting processes.[168]

Minnesota Voluntary Mercury Reduction Agreements

A 1999 Minnesota law required the Pollution Control Agency to solicit voluntary mercury reduction agreements from sectors that use or release mercury. MPCA's 2001 report to the legislature on the progress of this initiative found that fifteen agreements are in place. Most participants have developed important new information that may lead to future reductions. However, with some notable exceptions, the agreements have produced few measurable mercury reductions or long-term reduction commitments to date.[169]

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[165] Michigan Mercury Pollution Prevention Task Force. *Mercury Pollution Prevention in Michigan: Summary of Current Efforts and Recommendations for Future Activities*. April 1996. Ecology Center,
Great Lakes United, University of Tennessee Center for Clean Products and Clean Technologies. *Toxics in Vehicles: Mercury.* January 2001

[166] Federal Register: October 5, 2007 (Volume 72, Number 193).

[167] U.S. EPA Region 9, Nevada Mining Partnership Program, http://www.epa.gov/region09/innovations/mining.html, accessed April 29, 2009.

[168] Nevada Department of Environmental Protection, *Nevada Mercury Control Program Briefing Document*, January 2007, http://ndep.nv.gov/mercury/mercury_briefing0207.htm, accessed April 29, 2009.

[169] Minnesota Pollution Control Agency, *Mercury Reduction Program: Progress Report to the Minnesota Legislature.* January 2002

MPCA's 2005 report found that voluntary agreements with electric utilities and the state's largest sewage treatment authority had achieved some reductions in emissions from coal-fired power plants and a sludge incinerator. MPCA had determined that 93 percent reduction in mercury emissions statewide from 1990 levels would be needed to meet the requirements of the statewide Minnesota mercury TMDL, with reductions required in particular from the largest remaining sectors: coal-fired power plants and taconite production facilities. However, the reductions achieved were fairly modest, equivalent to approximately three percent of 1990 emissions. Much more significant reductions had been achieved through state and federal regulatory requirements limiting the mercury content of paints, batteries and fungicides, and controlling emissions from waste combustors. Voluntary agreements also led to research on emissions controls at taconite facilities, to improvements in mercury waste management, and to increased public awareness. MPCA concluded that "achieving the reductions needed from all sectors will require additional voluntary and regulatory strategies."[170] Minnesota developed a subsequent voluntary program to involve stakeholders in TMDL implementation, securing significant reduction commitments from the taconite industry and others (see section 6.3). For coal-fired power plants, Minnesota imposed a state-wide regulation, after extensive consultation with industry.

6.5 Lessons Learned

Some lessons can be learned from this review of voluntary mercury reduction programs:

- Information is power. In order to promote voluntary efforts to address an environmental problem, it is vital to have publicly-available information that shows persuasively that the problem exists.
- Voluntary efforts can be shaped by the regulatory environment. While no regulation required Nevada gold mines to undertake mercury emissions reductions, the regulatory requirement to report to the Toxics Release Inventory was a vital catalyst to the voluntary reduction program. State laws imposing mercury switch recovery responsibilities on the auto industry and prospective federal regulation imposing such responsibilities on the steel industry were an important factor in the creation of the National Voluntary Mercury Switch Recovery Program.
- Voluntary efforts can shape mandatory controls. Voluntary efforts can demonstrate the feasibility and environmental value of control methods in a portion of an industry. Sometimes regulations rely on the example of the voluntary effort, and make mandatory the controls voluntarily adopted by industry leaders. In such cases, industry leaders who have voluntarily adopted controls may support regulation to level the playing field.
- Sometimes you just have to ask: some industries, such as the gold mining industry and the chlor-alkali industry, have been willing to undertake significant voluntary efforts when requested to do so.
- Sometimes asking is not enough. While an open "challenge" to industry to undertake voluntary action can be successful, sometimes a more painstaking process of stakeholder involvement and negotiation is needed in order to achieve results. Sometimes even a carefully-constructed voluntary program will not be sufficient, and regulation will be necessary.

6.6 Recommendations

- Recommendation 31: States should continue to promote awareness of mercury issues.
- Recommendation 32: States should consider voluntary approaches along with regulatory approaches when addressing mercury emissions sources.

7.0 TRACKING PROGRESS ON IMPLEMENTATION

7.1 Track Progress on Implementation of Recommendations

[170] Minnesota Pollution Control Agency, *2005 Mercury Reduction Progress Report to the Minnesota Legislatur*e.

An ongoing system of governance and organization for follow-up on this strategy would facilitate the successful implementation of this strategy. A workgroup – perhaps including many of the drafters of this document – should be formed to periodically evaluate progress. States and U.S. EPA could appoint representatives to this group. In addition, Environment Canada and the Ontario Ministry of the Environment could be invited to participate, helping promote information sharing on successful mercury reduction approaches across the Great Lakes region. Input from stakeholders, including U.S. and Canadian industry and environmental groups, should be sought.

The proposed group could meet twice per year, at least initially. At workgroup meetings, state, tribal, and municipal representatives could discuss with one another the progress being made in mercury reduction in their areas. Additionally, the group could compile a progress report biennially (every two years) for submission to the Council of Great Lakes Governors. This report will be made available to regional, national, and international audiences. It will identify individual states' (and, where available, tribes' and cities') successful implementations of this strategy's recommendations and may also include other progress relative to mercury reduction. The biennial report will provide organizational structure for this project through 2015.

7.2 Identify Implementation Priorities

- Recommendation 33: Each of the Great Lakes state environmental agencies should publicly identify its implementation priorities and the organizations responsible for achieving them.
- Recommendation 34: Each of the Great Lakes States environmental agencies and the U.S. Environmental Protection Agency should appoint a representative to a workgroup tasked with tracking progress on implementation of the recommendations in this report and for sharing information about implementation priorities and approaches. This workgroup should invite participation from Environment Canada, the Ontario Ministry of the Environment, and Quebec's Ministry of Sustainable Development, Environment and Parks, and seek stakeholder input.

APPENDICES

Appendix A – Great Lakes Regional Collaboration

The Great Lakes are a unique and extraordinary natural resource providing drinking water, food, recreation, employment, and transportation to more than 35 million Americans. But the Great Lakes suffer from many serious environmental challenges. Since 1970, much has been done in attempts to restore and protect the lakes. Although there has been significant progress, the work of cleaning up the lakes and preventing further problems has not always been coordinated.

Learning that the protection of the Great Lakes was in need of better coordination, in May 2004, President Bush created a cabinet-level interagency task force and called for a "regional collaboration of national significance." As a result, the federal Great Lakes Interagency Task Force, the Council of Great Lakes Governors, the Great Lakes Cities Initiative, Great Lakes tribes and the Great Lakes Congressional Task Force convened a group now known as the Great Lakes Regional Collaboration (GLRC). The Collaboration includes the EPA-led Federal Interagency Task Force, the Great Lakes states, local communities, tribes, non-governmental organizations and other interests in the Great Lakes region. While the Collaboration is a U.S. effort, its members do everything possible to synchronize its efforts with those of our Canadian partners.

The Collaboration created a strategy to restore the Great Lakes basin, which was released on December 12, 2005. Subsequently, Issue Area Strategy Teams were created and charged with developing detailed recommendations on how to accomplish the goals of the strategy. Eight Issue Area Strategy Teams include:

- Aquatic invasive species
- Habitat conservation and species management
- Near-shore waters and coastal areas (Coastal health)
- Areas of concern
- Non-point sources
- Toxic pollutants
- Sound information base and representative indicators
- Sustainability

The teams were made up of subject-matter experts from many diverse backgrounds: more than 1,500 people from all levels of government and nongovernmental organizations worked on the issues identified as crucial to the health of the Great Lakes ecosystem. The teams were the working bodies responsible for drafting action items and recommendations to address the eight issues.

In addition, the teams have addressed the following overarching considerations and topics:

- Human health impacts and priorities
- Tribal interests and perspectives
- Research and monitoring

On July 7, 2005, the GLRC released its draft strategy document for public view and comment. The Strategy included detailed recommendations addressing the eight Issue Areas.

Appendix B – page 47 of the GLRC Strategy: Toxic Pollutant Strategy

I. Problem Statement

While certain persistent toxic substances (PTS) have been significantly reduced in the Great Lakes Basin Ecosystem over the past 30 years, they continue to be present at levels that pose threats to human and wildlife health, warrant fish consumption advisories in all five lakes, and disrupt a way of life for many in the basin, particularly the ways of life and cultures of tribal communities.

PTS releases from contaminated bottom sediments, various industrial processes, and non-point sources, loadings from atmospheric deposition, contaminated groundwater, and continuous cycling of PTS within the Great Lakes themselves, all contribute to this ongoing problem. More recently, researchers have documented the presence of additional chemicals of emerging concern that may also pose threats to the Great Lakes. Characteristics of these substances, such as sources, releases, fate, transport, persistence, bioaccumulation, and toxicity, must be better understood.

II. Goals and Milestones

To establish and maintain the chemical integrity of the Great Lakes Basin Ecosystem, as called for in the Great Lakes Water Quality Agreement, this Strategy sets forth the following goals:

Goal 1: Virtually eliminate the discharge of any or all persistent toxic substances (PTS) to the Great Lakes basin ecosystem.
Goal 2: Significantly reduce exposure to persistent toxic chemicals from historically contaminated sources through source reduction and other exposure reduction methods.
Goal 3: Reduce environmental levels of toxic chemicals to the point that all restrictions on the consumption of Great Lakes fish can be lifted.
Goal 4: Protect the health and integrity of wildlife populations and habitat from adverse chemical and biological effects associated with the release of PTS.

Interim Milestones, Goals 1-4:

By 2008, collect 1 million pounds waste pesticides per year.
By 2010, 50 percent reduction in basin-wide household garbage burning.
By 2010, commence significant reductions in mercury emissions from coal-fired power plants.
By 2015, full phase-outs of intentionally added mercury bearing products, as possible.
By 2025, full phase-out of all PCB equipment in the basin.
By 2025, significantly reduce PTS inputs from international sources.

Appendix C - Quicksilver Caucus's Action Plan and Implementation Strategy for Reducing Mercury in the Environment

Quicksilver Caucus Action Plan with Implementation Strategy
2007-2008

Goal – State, Federal, and International Actions Result in Net Mercury Reductions to the Environment

DRAFT DECEMBER 31, 2006

I. State Actions Make A Difference

Guiding Principles

- Preventing environmental degradation and protecting public health are the basis for state action
- Eliminating mercury contamination in one media should not result in significant contamination in another media
- Reducing emissions within a state is the first step towards reducing trans-boundary transport
- Working collaboratively and in partnership promotes trust and investment that yield environmental results

Framework for State Action Is in Place

- ECOS eight resolutions provide policy guidance(list attached)
- Stewardship documents provide policy and technical guidance
- TMDL document provides policy and technical guidance
- US EPA Roadmap for Mercury (July 2006) provides policy for QSC—US EPA Partnership

Key Quicksilver Caucus Actions

Actions and Activities	**Key Tasks** (What and How)	**Participants** (Who)	**Target Date** (When)
A. Strengthen State Capacity to Reduce and Manage Mercury in the Environment			
1. Assess Status of State Mercury Activities	Update Key Compendium Tables and Contacts and Publish on QSC Web Page	QSC Members QSC Staff	May 2007 May 2008
2. Product Stewardship	a. Implement Product White Paper Recommendations b. Facilitate Implementation of Multi-state Approaches c. Develop national mercury reduction programs for these, based on stakeholder input (modeled on the national vehicle switches program)	QSC Members QSC Staff	a. Summer 2007 b. Spring 2008 c. December 2008
3. Peer to Peer Knowledge Transfer on Vehicle Switches and 2 new Topics (one per year)	a. Vehicle Switches – continue monthly conference call b. Determine Topics, Audiences, Materials	QSC Members QSC Staff	a. Ongoing b. Fall 2007 & Summer 2008

Actions and Activities	**Key Tasks** (What and How)	**Participants** (Who)	**Target Date** (When)
	Based on Update of Compendium Materials and Discussions with QSC Members and US EPA c. Develop Technical Information Materials (e.g., Best Practices, Success and Failure Stories, Fact Sheets, Brochures, etc.,) d. Schedule and Hold Technical Seminars (Structured Conference Calls)		c. Fall 2007 & Summer 2008 d. January 2008 & October 2008
4. Mercury Switches in Vehicles	a. Implement State Responsibilities for NVMSRP b. Work with Implementation Steering Committee to Develop Measures of Program Progress in Meeting Goals c. Participate In Program Evaluation and Communication of Program Results	Peggy Harris John Gilkeson ECOS Staff – Mary Blakeslee	a. On-going b. February 2007 c. August 2007 & August 2008
B. Foster Safe Long-term Management of Elemental Mercury			
1. Coordinate Effective State Participation in Development of National Strategy for Safe Long-term Storage of Elemental Mercury[1]	Work Collaboratively with US EPA to Define and Implement Approach and Schedule	QSC Members QSC Staff	On-going
2. Develop State Principles and Policy on Sound Environmental Management of National and International Stockpiles of Elemental Mercury	a. Consult with Federal and International Partners to Understand their Perspectives b. Establish ECOS Resolution (new or modified) to support desired State approach	QSC Members QSC Staff	Fall 2007
C. Educate and Engage Key Public and Private Sector Leaders			
Brief State and Federal Environmental Policy leaders, State and Federal Legislators, NGOs and	a. Updates at Appropriate Venues b. Publish Factsheets, Journal Newsletters, etc.	ECOS Officers and Members, QSC Leaders and	On-going as Appropriate

[1] This activity continues to be a high priority for the QSC and States

Actions and Activities	**Key Tasks** (What and How)	**Participants** (Who)	**Target Date** (When)
Private Industry	c. Send Letters as Appropriate	Members	
D. Position QSC to Implement Action Plan			
1. Continue State Leadership Commitment	a. QSC Leaders Seek Endorsement by Respective Organizations of QSC Plans, Policies, & Programs b. QSC Identify Actions to Support and Enhance QSC Plans, Policies, & Programs	QSC Leaders and Staff	On-going as Appropriate
2. Continue QSC Outreach	Evaluate Outreach Approaches Focus Outreach on Key Actions and Activities	QSC Members QSC Staff	On-going as Appropriate
3. Organize QSC Members	a. Form Implementation Teams b. Provide Logistics for QSC Teams	QSC Leaders ECOS Staff	On-going
4. Develop and Obtain Funding for QSC 2009-10 Action Plan	Develop Action Plan Documents	QSC Leaders QSC Staff	November 2008
E. Educate State and Federal Policy Leaders in May 2007			
Host Third Policy Leaders Workshop	a. Finalize Agenda b. Hold Workshop c. Develop or Revise Policy and Program Recommendations for QSC-US EPA Consideration	Mark McMillan and Mark Smith, Leaders QSC Members and Staff	a. February 2007 b. May 2007 c. July 2007

II. Implementing US EPA's Roadmap for Mercury

Guiding Principles

- Interim Storage and Long-term Management of Elemental Mercury (e.g. in Public Stockpiles and from closures and collections) Is a Federal Responsibility
- US EPA's Roadmap for Mercury Provides the Framework for the State-Federal Partnership
- US EPA, in Consultation with the States, Develops Comprehensive National Implementation Plan for their Mercury Roadmap in order to facilitate effective actions
- Mercury in the Environment Is a Global Issue and Requires United States Leadership In Developing Reduction Strategies
- Federal Government Should Lead By Example
- State Policy and Technical Leaders Should Be Consulted in Developing National and International Policy and Programs
- State Experience and Expertise Are a Resources Should Be Integrated Into National and International Programs

Key Elements of a Federal Framework

- DOD's Interim Solution For Storing and Managing Its Mercury Stockpile
- US EPA Roadmap for Mercury, including:
  - Regulatory Actions, Policies and Programs for Managing Air, Water, and Land Releases
  - Product Stewardship Programs
  - Managing Commodity Grade Mercury, Including Development of Interim Solutions For Storing and Managing Federal (DOE and other Federal agency) and Private Mercury Stockpiles
  - Risk Communication
  - International Sources
  - Research and Development Programs

Key Quicksilver Caucus Actions

Actions and Activities	**Key Tasks** (What and How)	**Participants** (Who)	**Target Date** (When)
A. Continue to Support National Leadership Approaches to Reduce and Safely Manage Mercury in the Environment			
1. Continue to Support the Safe, Long-term Storage of the DOD Mercury Stock Pile	Monitor Department of Defense Actions	QSC Members QSC Staff	On-going as Appropriate
2. Monitor and Recommend Appropriate Action for Safe, Long-term Storage of the DOE Mercury Stock Pile	Monitor Department of Energy Actions	QSC Members QSC Staff	On-going as Appropriate
B. Implement Roadmap Through QSC- US EPA Partnership			
1. Support Development of	a. Form QSC Team to work with US EPA	QSC Members	Spring 2007

Actions and Activities	**Key Tasks** (What and How)	**Participants** (Who)	**Target Date** (When)
Detailed Implementation Plan	b. Present and discuss at May Senior Leaders Workshop	QSC Staff	
2. Enhance States Engagement in Development of US EPA Regulations, Policy, Guidance, and Programs to Reduce Mercury Releases a. Air Releases b. Water Releases c. Land d. Toxic Release Inventory	a. Air Releases i. Continue to Participate in NACAA and ECOS Issue Position Development and Dialogue with US EPA and the Development of NACAA and ECOS Policy ii. Collaborate with NACAA to Facilitate Information Sharing and Collaboration Across States b. Water Releases i. Mercury Impaired Waters -- Continue to Participate in ASIWPCA and ECOS Issue Position Development and Dialogue with US EPA and the Development of ASIWPCA and ECOS Policy ii. Collaborate with ASIWPCA to Identify Additional Sources (e.g., sludge) and Control Approaches c. Land i. Continue to Participate in ASTWMO, P2 Roundtable and ECOS Issue Position Development and Dialogue with US EPA and the Development of ASIWPCA and ECOS Policy ii. Support US EPA in Developing Specific Approached to Address Mining d. TRI – Support US EPA approaches as appropriate	QSC Members QSC Staff	Ongoing with Specific Issues and Dates Determined In Concert with US EPA
3. Sustain State Momentum to Reduce Mercury in Products and Processes By Encouraging US EPA to Collaborate with States in Developing National Approaches	a. Implement Product White Paper Recommendations b. Facilitate Implementation of Multi-state Approaches Identify one to two key sectors c. Develop national mercury reduction programs for these, based on stakeholder	QSC Members QSC Staff	a. Summer 2007 b. Spring 2008 c. December 2008

Actions and Activities	**Key Tasks** (What and How)	**Participants** (Who)	**Target Date** (When)
	input (modeled on the national vehicle switches program)		
4. Inform United States Positions and Enhance Federal Resources to Promote Reduction of Mercury in the International Arena	a. Support U.S. Positions by Providing Early and On-going Consultation and Advice in Trans-boundary Activities with Mexico and Canada b. Participate with US EPA in UNEP Partnership Identify Key Actions and Opportunities for Involvement c. Create Implement Network of State Consultants to Leverage US Agreements with International Organizations d. Implement Network of State Consultants to Leverage US Agreements with International Organizations	QSC Members QSC Staff	a. Ongoing b. Winter 2007 c. Summer 2007 d. Ongoing
5. Foster the Development of a National and International Framework that Ensures Current and Potentially Growing Supplies of Commodity Grade Mercury Are Used Only For "Essential" Uses	a. Partner with US EPA to Have a National Forum that Engages Interested Parties in Dialog b. Partner with US EPA to Create US Markets that Reduce Use of Products Containing Mercury c. Encourage tracking of international trade, use, recovery and disposal of mercury. d. Encourage development of policies and techniques for long-term storage should be developed. e. Develop White Paper Documenting State Actions to Establish Market-based Approaches for Reducing Use of Mercury In Products and Processes	QSC Members QSC Staff	Ongoing with Specific Issues and Dates Determined In Concert with US EPA
6. Support Effective Communication	a. Work with US EPA Provide Public Effective and Accurate Consumer Information on their Website focusing on mercury products b. Develop Measures that Document the Effectiveness Communication Tools	QSC Members QSC Staff	Ongoing with Specific Issues and Dates Determined In Concert with US

Actions and Activities	**Key Tasks** (What and How)	**Participants** (Who)	**Target Date** (When)
			EPA
7. Support Increased Resources for Existing US EPA Research and Monitoring to Better Data and Information	a. Work with US EPA to Establish Regional Research and Development Conferences Program b. Encourage US EPA to evaluate new treatment technology and discuss findings with QSC and others c. Encourage expansion of the mercury deposition network d. Work with US EPA to support USGS monitoring and reporting of commodity mercury	QSC Members QSC Staff	Ongoing with Specific Issues and Dates Determined In Concert with US EPA
8. Encourage US EPA to Undertake Economic Research to Identify Market-based Incentives for Mercury-Free Products	Create Team to work with US EPA to explore approaches	QSC Members QSC Staff	Ongoing with Specific Issues and Dates Determined In Concert with US EPA

ATTACHMENT – List of ECOS Mercury Resolutions

Resolution #	Title	Date	Expiration
01-1	Need for Articulation of a National Vision for Mercury	April 7, 2004	April 7, 2007
03-3	Mercury Stewardship	March 21, 2006	March 21, 2009
03-7	The Need for a National Mercury Reduction Strategy as an Option for Atmospheric Mercury Total Maximum Daily Loads (TMDLs)	August 29, 2006	August 29, 2009
04-2	Regarding a Mercury Emissions Rule	April 20, 2004	April 20, 2007
04-7	Need for Nationwide Mercury Switch Removal Strategy that Provides Flexibility to the States	October 5, 2004	October 5, 2007
05-3	Need for State EPA Approach for Reducing Mercury on the Environment	April 11, 2005	April 11, 2008
06-1	Mercury Retirement and Stockpiling	March 21, 2006	March 21, 2009
06-7	Endorsement of National Mercury Switch Removal Program Memorandum of Agreement that Reduces Mercury in the Environment and Provides Flexibility to the States	August 17, 2006	August 11, 2009

Appendix D - Michigan Operating Procedure – Great Lakes Air Permitting Agreement

OPERATING PROCEDURE
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
AIR QUALITY DIVISION

SUBJECT: Implementation of the Great Lakes States Air Permitting Agreement

EFFECTIVE DATE: February 1, 1990

Preamble

On November 3, 1988, the representatives of the Council of Great Lakes Governors entered into the Great Lakes States Air Permitting Agreement (Attachment A) This agreement addresses the control of toxic emissions in the Great Lakes Basin to minimize the impact of toxics on the Great Lakes. The purpose of this Operating Procedure is to implement the Agreement through the permitting process within the State of Michigan.

General Policy

It is the policy of the Air Quality Division, Permit Section, to review all permit to install applications for the emission of those seven compounds listed in the Agreement (and others as they may be added), to require Best Available Control Technology (BACT) on those processes emitting those compounds consistent with our rules, and to communicate such toxics information to other Great Lakes states and to the BACT/LAER Clearinghouse and the National Air Toxic Information Clearinghouse.

Procedures

The following procedures shall be followed in the evaluation of any application for a permit to install any new or modified source of a listed toxic air contaminant.

1. As part of the normal permit review for compliance with the rules, including environmental acceptability, the permit engineer shall determine if the subject process has the potential to emit any of the following compounds, using the guidelines provided in Attachment B:

- Mercury
- Alkylated Lead Compounds
- Total Polychlorinated Biphenyl
- Hexachlorobenzene
- Benzo-a-pyrene
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin
- 2,3,7,8-Tetrachlorodibenzofuran

2. The permit engineer shall determine, from the permit application and by working with the applicant, the emission level of these compounds and shall quantify these emissions in the permit application.

Appendix E - Detailed Breakout of Mercury Emissions Sectors, Using NEI-designated Source Categories

2005 NEI NATA, 072009 (tons)	Great Lakes States Total	IL	IN	MI	MN	NY	OH	PA	WI
Utility Boilers: Coal	19.8	4.2	2.9	1.8	0.7	0.4	3.7	4.9	1.1
Stainless and Nonstainless Steel Manufacturing: Electric Arc Furnaces (EAF)	3.4	0.8	0.4	0.2	0.1	0.1	0.7	1.0	0.0
Industrial/Commercial/ Institutional Boilers & Process Heaters	2.2	0.2	0.2	0.3	0.1	0.2	0.2	0.7	0.3
Hazardous Waste Incineration	1.6	0.0	1.3	0.0	0.0	0.0	0.1	0.1	0.0
Portland Cement Manufacturing	1.4	0.1	0.2	0.6	0.0	0.3	0.0	0.3	0.0
Chemical Manufacturing	1.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.6
Municipal Waste Combustors	0.8	0.0	0.0	0.0	0.1	0.4	0.0	0.2	0.0
Residential Heating: oil	0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.0
Secondary Nonferrous Metals	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fluorescent Lamp Breakage	0.4	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Incineration: On-site	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Taconite Iron Ore Processing	0.4	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Landfills: Municipal	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iron and Steel Foundries	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Ferroalloys Production	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Dental Amalgam Production	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Secondary Lead Smelting	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Primary Aluminum Production	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Sewage Sludge Incineration	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Integrated Iron & Steel Manufacturing	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Utility Boilers: Oil	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electrical and Electronics Equipment Manufacturing	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Mobile	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Laboratory Activities	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brick and Structural Clay Products Manufacturing	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Petroleum Refineries	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mineral Products: Gypsum Products	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cremation: Human	0.05	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00
Other	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Total	34.9	6.6	5.5	3.4	1.6	2.1	5.7	7.8	2.3

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