

## Frequently Asked Questions about Mercury

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## 1. What are the sources of mercury?

Mercury is a natural component of the earth's geology. It is present in small quantities in fuels such as coal and oil which are extracted from the earth. Human activity, including industrial activity, may increase the release of mercury into the environment. Current estimates are that, globally, human activities mobilize about 2400 (U.S.) tons of mercury a year into the atmosphere. Of this, the United States releases about 130 tons annually, about 46 tons of which come from power plants. Thus the U.S. releases less than 5%, and U.S. power plants less than 2%, of the global total of human-caused mercury emissions. In terms of total mercury emissions, both natural and human-caused, U.S. power plants contribute less than 1% to the global pool.

Globally and in the U.S., mercury can enter the atmosphere from combustion sources, such as power plants, factories, incinerators, and motor vehicles. In addition, some sources, such as chemical plants, petroleum refineries, and smelters may release mercury into air and water primarily from their process technologies and secondarily from fuel combustion. However, as individual categories of sources, their mercury emissions are all lower than those of the electric generation sector.

Natural sources, including geysers and volcanoes, and waste material around abandoned metal mines are believed to equal or exceed these human-caused sources of mercury emissions. Underwater volcanoes or cracks in the earth's crust are also believed to release significant levels of mercury directly into the ocean and, eventually, into the atmosphere.

See also [Mercury in the Environment: Its Sources and its Deposition.](#)

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## 2. How much mercury does coal contain? Does the amount vary in different types of coal?

Mercury is present in coal in trace quantities (less than 1 part per million is typical). Eastern bituminous coals tend to contain about 1/3 more mercury than western coals. Lignite coal, which makes up a small fraction of the coal burned in the U.S., has a mercury

content which varies considerably but is generally 2 to 3 times as high as other coal types.

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## 3. What are the different types of mercury?

There are two major forms of mercury emitted during the combustion of coal – oxidized (or divalent), which is water-soluble, and elemental, which is not very water-soluble. While rainfall can wash some of the oxidized mercury in the atmosphere down to the earth's surface, and a portion of that into local rivers, lakes, and streams, essentially all the elemental mercury and most of the oxidized mercury is carried away from any atmospheric source by the wind and thus enters the global mercury cycle.

A very small fraction, perhaps one-tenth of one percent, of the oxidized mercury that ends up in waterways may be changed into an organic form called methylmercury. (Methylmercury is not emitted to the atmosphere directly by combustion or other sources.) It is this form that can be taken up by organisms in the water that are then eaten by small fish. As progressively larger fish eat the smaller ones, the mercury levels in the fish can accumulate and thus be found in greater concentrations higher up the food chain. Mercury in fish has the greatest potential to reach members of the human population.

See also [Mercury in the Environment: Its Sources and its Deposition.](#)

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## 4. Is mercury a health hazard?

There have been three major accidental mercury poisoning incidents – two in Japan in the 1950s, and one in Iraq in the 1970s – where people ate massive amounts of organic mercury (methylmercury) in contaminated food. Their exposure levels were hundreds of times higher than any mercury exposure in North America today. In these accidental poisoning cases, the children and adults exposed to the highest amounts of mercury experienced kidney, brain, and nerve damage, while some died.

Researchers studying the after-effects of the Iraq accident observed that it took less methylmercury to affect children exposed as fetuses than it did to affect adults. Therefore, researchers began to focus on women who consume fish on a sustained basis during pregnancy to determine if these very low level, but ongoing, exposures to mercury heighten their developing babies' risk of delayed starts in walking and talking, slow their responses to stimuli, and cause other subtle effects.

The U.S. Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), and various states have issued guidelines regarding fish consumption by pregnant women and young children.

Most Americans, however, eat very little fish. Many Americans eat no fish whatsoever and, of those who do, the weekly average consumption is about one-quarter pound. Nearly all of this fish is store-bought ocean fish, primarily from the North and South Pacific, which is unlikely to contain much mercury emitted solely from U.S. sources. On average, less than 10% of fish eaten in the U.S. comes from U.S. freshwater sources, although some anglers and others may consume larger amounts. Further, much of the consumed fish in the U.S. is "farm-raised" using controlled feed that is mercury-free.

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### **5. What are the health effects of mercury at typical exposure levels? How many children are currently "at risk" from mercury exposure?**

Because the human body naturally eliminates mercury, most researchers believe that occasional exposure to the relatively small amounts of mercury in the U.S. environment has no substantial effect on human health. The chief public health concern about mercury is the potential for developmental impacts on young children. Children are primarily exposed to mercury prior to birth if their mothers consume mercury-tainted fish while pregnant. The U.S. Environmental Protection Agency has developed a regulatory standard for mercury ingestion for women of childbearing age that is called the Reference Dose.

The EPA Reference Dose was developed largely by examining the results of tests administered to children living in the Faroe Islands in the North Atlantic, where the predominant food sources are locally caught fish, which contain very little mercury, and pilot whale, containing higher levels of mercury. Because of this diet, children in the Faroes are known to experience a range of mercury exposures. Researchers tested nearly 1000 seven-year-old children who were routinely exposed to mercury prior to their birth via their mothers' diet that included whole meals of pilot whale. Under the test protocols used, the performance of some of the children with greater mercury exposure was slightly lower on tests measuring subtle behavioral and developmental differences.

To set the U.S. regulatory standard, the EPA determined the lowest level of mercury intake by mothers at which effects were observed in the Faroese children on the most sensitive of these tests. They then applied an adjustment factor that lowered this level by a factor of 10 to ensure that the most sensitive individuals are protected under any circumstances. That new, lower level became the Reference Dose.

The test used to set the Reference Dose (the Boston Naming Test), however, was originally designed to detect language disabilities in U.S. adults. When that test was applied to U.S. children, scientists found that the test measured acquired language skills rather than differences in development that substances such as mercury might cause. So the measurements used to set the mercury Reference Dose may well be based on results from a test that is not applicable to mercury. A further concern is that, in addition to mercury, the pilot whale contained other pollutants, including large amounts of polychlorinated biphenyls (PCBs), which mimic the effects of mercury on child development.

Continuing blood tests of U.S. women by federal agencies have recently found that none have mercury levels in excess of the "no-effects level" seen in the studies that established the Reference Dose. In fact, as more data have been collected, the small portion of women found to have mercury levels above the Reference Dose itself (i.e., one-tenth the "no-effects level") has gotten smaller. Children potentially born to these women form the group frequently referred to as

“at risk.” It is expected that further studies in the U.S. will show a continuing decline in these numbers.

See also [Mercury Controls, Regulations, and Public Health](#).

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## **6. Does mercury affect IQ or cause heart disease?**

Recent studies have linked mercury exposure in children to lower IQ scores and lowered lifetime earnings due to those lower scores. One group of authors assumed that lower scores on performance tests in children studied for mercury effects correspond to lower IQ scores. This assumption has no current basis in scientific evidence. IQ tests administered to mercury-exposed children in a New Zealand study showed no statistically supportable relationship between mercury levels and IQ changes. Other studies elsewhere have not used IQ tests on the childhood subjects.

Similarly, the calculated effect of IQ assumed a simple, direct relationship to lifetime earnings. Many studies have shown that the socioeconomic status of individuals and other factors are also important determinants of differences in income, but these were not considered in the estimates of mercury exposure/IQ/lifetime income.

The impacts of mercury exposure on adult heart disease are similarly poorly established. Most results showing a cardiovascular effect are based on repeated analyses of men in Finland with lifetime diets very different from those of U.S. adults. There are many more studies, including those of U.S. healthcare workers, showing no relationship between mercury exposure and heart disease. This is in addition to a number of investigations, including a recent comprehensive study from the Harvard School of Public Health, showing an overall beneficial health outcome from fish consumption even when mercury effects are considered.

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## **7. What about the mercury from power plants – how much is emitted and where does it go?**

About one-third of the mercury emitted into the air from industrial sources in the U.S. comes from power plants. Globally, U.S. power plants are responsible for about 2% of the total industrial mercury, or less than 1% of the mercury emitted from all sources (including natural emissions). After power plants release mercury, most of it stays aloft and becomes part of a global cycle. A portion of the water-soluble, oxidized mercury (which makes up about 40% of all U.S. power plant emissions) can be washed out of the air by rain or snow returning to the earth. Non-water soluble mercury (about 60% of power plant mercury emissions) usually travels farther in the atmosphere where it may remain for months or years, as it disperses to very low concentrations. Eventually, some of it also returns to the earth. These deposited forms of mercury may enter soil or bodies of water. Notably, for most of the U.S., over 60% of the mercury measured at monitoring stations, and thus deposited on land or water, originates outside the country.

Researchers are trying to determine how much mercury from power plants actually enters aquatic environments and how much is transformed to methylmercury, which has the potential to enter the food chain. Because it is difficult to track the path of elemental mercury—as it can travel around the world—and because mercury exists in so many forms in so many environments, determining the role of the various sources of mercury has remained elusive. Experiments underway now, such as the multinational METALLICUS (Mercury Experiment to Assess Lake Loading in Canada and the United States) field study, seek to clarify these various pathways in the environment. After five years of field studies and an additional year of analysis, some surprising findings are coming to light and being published. For example, measurements of “tagged” mercury deposited to the land surface from simulated rainfall found that only about 1/5<sup>th</sup> of the total was re-emitted to the atmosphere. This is a much smaller fraction than investigators had earlier thought would return to the atmosphere, and may mean that long-range transport of re-emitted mercury, called the “grasshopper effect,” is a much smaller contributor to mercury levels around the Arctic Circle than has been thought. In addition, recent findings showed that very

little of the mercury deposited throughout the watershed of a large lake ever reached the waterbody itself to become available to the fish. Most of the deposited mercury appears to remain chemically bound in the soils. One result of this could be that changes in fish mercury will be significantly delayed following large-scale changes in mercury deposition.

See also [Tracking Mercury's Movement in the Environment](#)

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## **8. What do we know about power plant mercury and local effects?**

As noted by the EPA in its 1997 Mercury Study Report to Congress, extensive measurements around power plants have never shown any local increase in mercury from these facilities at ground level or in nearby waterways. Indeed, more recent measurements at a large power plant in Maryland showed that patterns of mercury deposition around the plant were unrelated to the amount or the direction of power plant emissions. Computer models run by EPA and by EPRI similarly have shown that a relatively large change in power plant mercury emissions resulted in only slight changes in deposition nationally. The most recent study by EPA found that a 70% cut in national utility mercury emissions resulted in a 7% drop on average in mercury deposition. Some small, isolated areas are predicted to experience changes of up to 70% in deposition due to such a cut in power plant mercury emissions, but these areas represent only about one-tenth of one percent of the lower 48 states land area. And in many cases, the 70% reduction in deposition is at locations where mercury deposition is already rather small.

For more on this see [Tracking Mercury's Movement in the Environment](#), [Mercury "Hot Spots"—Emissions and Deposition Patterns](#), and [Mercury Controls, Regulations, and Public Health](#).

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## **9. What are the public health risks due to power plant mercury emissions today? How will the risks change following implementation of EPA's new mercury rules? Would more stringent controls further reduce exposure?**

Investigating the impact of mercury on public health is complicated by how it cycles through atmospheric, aquatic, and marine environments. Because of these complex cycles, we must rely on computer simulations using the best scientific data to determine its impact. Both EPRI and EPA have simulated (modeled) the individual emissions of over 600 U.S. coal-fired power plants. This modeling has repeatedly found there is a very small likelihood that any U.S. resident is currently exposed to mercury at adverse levels caused solely by power plant emissions. EPRI model results indicate, at most, a 0.6% chance that a U.S. resident anywhere near a power plant is currently exposed to mercury originating from power plant emissions at a level exceeding EPA's Reference Dose. That probability drops by a factor of 15, to 0.04%, following implementation of EPA's mercury-related regulations, the Clean Air Mercury Rule (CAMR) and the Clean Air Interstate Rule (CAIR).

The key route for human mercury exposure is through consumption of mercury-tainted fish by pregnant women who could expose their developing fetuses to methylmercury. The highest concentrations of mercury occur in large predatory fish such as pike, walleye, and swordfish. In analyses conducted by EPRI, fish consumption patterns across the U.S. were examined state by state. Data from the Federal health survey were used to identify the "most sensitive" women, i.e., those who showed the greatest mercury levels per amount of fish consumed. Both freshwater and marine fish consumption, as well as that of "farmed" fish, were considered in the analysis. About 90% of all fish consumed in the U.S. are marine fish, and most of these are landed in distant Pacific waters.

These analyses showed that exposure of the most sensitive U.S. women to mercury will drop, on average, 1.5% by 2020 under the new mercury rules. For many western states, the change in exposure will be less than 1%, while the greatest reduction (in West Virginia) will be about 7%. Similar numbers and patterns have been derived by independent studies carried out by the EPA.

Both EPA and EPRI findings show that if utility mercury emissions were further reduced beyond the 70% cut anticipated under the new rules, the resulting additional exposure changes would be very small. This is because most of the additional mercury that would be controlled is predicted to be the insoluble elemental form, most of which leaves the U.S. under any circumstances. Thus the additional controls would have little impact on mercury deposition throughout the U.S.

For more on this subject, see [Mercury Controls, Regulations, and Public Health](#).

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### **10. To what extent do control technologies in use at utilities today reduce mercury pollution?**

On average across U.S. coal-fired power plants, technologies installed as of 1999 to reduce particulate, NO<sub>x</sub>, and SO<sub>2</sub> emissions captured about 40% of the mercury that entered the boilers with the coal. However, the removal rate of mercury for any particular plant varied from less than 10% to over 90%, depending on the type of coal and the air pollution control devices used. That range continues to-date. As more plants install advanced controls for NO<sub>x</sub> and SO<sub>2</sub>, the national average mercury capture rate will increase. In addition, about one-third of the eastern bituminous coal burned in power plants is cleaned before it is shipped to the plant, and this process removes, on average, 25-35% of the mercury in the coal.

For more on this subject, see [Status of Mercury Controls for Coal-Fired Power Plants](#). See also [Mercury Controls for Power Plants: An Illustration of the Options](#).

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### **11. What technologies are under development to specifically control mercury? When will they be commercially available?**

Reliable, cost-effective, predictable control technologies designed specifically for capturing mercury have not yet been fully demonstrated and proven over time. EPRI, the U.S. Department of Energy, and other researchers are in advanced stages of demonstrating several technologies and earlier stages of investigating other technologies.

One option is to inject materials (such as finely ground activated carbon particles) into flue gases to adsorb or react with mercury and produce solids that can subsequently be captured by particulate control devices. Recently a few suppliers developed chemically-enhanced versions of these sorbents, and these have shown high mercury removals on western coals in 1- to 30-day tests. Another potential method under investigation is to inject chemicals into the boiler, or insert structures coated with catalysts into the flue gas, to produce the soluble compounds of mercury that can be captured by SO<sub>2</sub> controls. For eastern bituminous coal-fired boilers, the catalysts used for NO<sub>x</sub> control, called "selective catalytic reduction" (SCR) systems, can serve this purpose. Current tests are determining how and under what conditions these catalysts can produce very high proportions of the water-soluble form of mercury. Another potential technology is attempting to adsorb the mercury onto solid structures placed in the clean flue gas stream following the particulate and SO<sub>2</sub> controls.

In all cases, field experience is needed to determine the emission levels that these technologies can sustain over the long term during normal power plant operation as well as any impacts they may have on power plant reliability and operation, any secondary emissions that may arise (e.g., the release of the chemical used to treat the new sorbents), the potential impact on coal combustion product use (fly ash or the gypsum produced by many SO<sub>2</sub> scrubbers), and their costs in commercial operation. Many field tests and laboratory programs aimed at evaluating a range of mercury control technologies are being conducted by the U.S. Department of Energy, industry, and EPRI. At the conclusion of these field tests in 2009, we should have a better understanding of the capabilities of these technologies and any further work needed to

bring them to broad commercialization.

For more on this subject, see [Status of Mercury Controls for Coal-Fired Power Plants](#). See also [Mercury Controls for Power Plants: An Illustration of the Options](#).

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## **12. How much mercury are the various technologies expected to remove? How much will these technologies cost?**

Mercury reduction technology studies have resulted in mercury removal between zero and 90+% in short-duration tests across the range of technologies being tested. Researchers do not understand all the reasons behind this variability but are gaining substantial knowledge through studies conducted by DOE, EPRI, and the technology community. At plants burning eastern bituminous coals and equipped with an SCR and SO<sub>2</sub> control (as will be required for many plants in order to comply with the Clean Air Interstate Rule [CAIR]), 75-90+% reductions in mercury emission have been measured in short-duration tests. For plants burning low-sulfur bituminous coal or a western coal, such as the widely used Powder River Basin (PRB) coal, the injection of activated carbon or chemically-treated activated carbon has resulted in similar mercury reductions in studies lasting 1 to 30 days. Sustainable, long-term averages will likely be at the middle to lower end of this range.

Costs for conventional activated carbon injection (the most common mercury-specific control under evaluation and currently practical only for low-sulfur coals), are estimated to be 0.05-0.3¢/kWh (compared with a typical electricity cost of 6-8¢/kWh for a customer in the Midwest). These costs depend strongly on the type of fuel burned, pollution controls used for particulate and SO<sub>2</sub> emissions, and required mercury reductions/limits. Costs will be higher if ash sales are lost or plants are required to reach 90% or greater removals and additional technology, such as a separate baghouse, must be employed to remove the sorbent-containing mercury.

See also [Status of Mercury Controls for Coal-Fired Power Plants](#).

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## **13. What is EPRI doing to understand and resolve questions about mercury?**

For about two decades, EPRI has been conducting research on all aspects of mercury – sources, movement, and chemical transformation in the environment as well as health effects and methods to reduce emissions. EPRI has worked closely with over a dozen state and federal agencies including DOE and EPA. In addition, EPRI has issued many publicly available technical reports and has published numerous papers in the peer-reviewed literature on all aspects of mercury science and technology.

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## **14. Explain mercury “hot spots.” How will EPA’s new mercury rules based on a cap-and-trade program affect “hot spots”?**

A number of scientists and others have raised the concern that allowing emissions trading in a mercury reduction rule would result in the creation of “hot spots,” or areas of elevated mercury deposition. However, there is no evidence from data or from computer simulations that “hot spots” currently exist due to any single power plant or any group of power plants.

In an emissions cap-and-trade program, such as that issued by the EPA in the CAMR mercury regulation, overall power plant mercury emissions must be reduced below a fixed cap nationally. This is to be accomplished by EPA allotting each state a fraction of this national cap for it to distribute among the coal-fired power plants in that state. Power plants that would incur the highest cost to reduce mercury emissions could purchase credits from power plants that control mercury beyond their own allotment and thus have emissions credits to sell.

While these mercury credit transactions would allow the buyer to purchase credits rather than reduce mercury at specific power plants, mercury emissions nationally would still decline as an overall cap on emissions would need to be reached. EPRI computer modeling has shown that none of the 253 power plants with mercury emissions over 100 pounds per year in 2004 would increase their emissions and only six (of these 253) plants would remain at current mercury emission levels. All others would lower their

emissions to required levels by 2020.

Additionally, the cost of purchasing credits still motivates power plants to reduce emissions as much as possible. Thus, when the new national cap on mercury emissions is implemented by the EPA and the states, a movement away from “hot spots,” rather than their creation, would be expected.

Many of the large plants burning eastern bituminous coal will continue to retrofit SO<sub>2</sub> and NO<sub>x</sub> controls and, in so doing, will remove a large fraction of the oxidized form of mercury, the form most likely to deposit via precipitation. The purchasers of the resulting credits are currently expected to be those likely to emit higher proportions of the elemental form of mercury; these emissions tend to leave U.S. territory completely and deposit at very small levels globally after extended circulation in the atmosphere.

EPRI computer analyses of the entire United States showed that areas of highest mercury deposition are not dominated by electric utility mercury emissions. Additionally, all U.S. locations that currently do receive more than half of their deposited mercury from U.S. power plants will have substantial reductions in mercury deposition following implementation of EPA's cap-and-trade program. These reductions will occur whether the total amount of mercury deposited at these locations is currently small, as in much of the western U.S., or somewhat greater, as in some eastern U.S. locales. Indeed, EPA's own analyses show that growth in emissions from non-utility sources in the U.S. will continue to drive deposition changes even following the new mercury rule for coal-fired power plants.

For further information on hot spots, see [Mercury Hot Spots – Emissions and Deposition Patterns](#)

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### **15. What about the Steubenville, Ohio, study stating that most mercury there comes from “local and regional” coal sources?**

A mercury deposition study in Steubenville, Ohio, conducted by the University of Michigan and sponsored by the EPA has concluded that local and regional emissions from power plants contribute more

than 60% of the mercury deposited via precipitation at that particular monitoring site. According to the authors of that study in public testimony, the contributing sources may be as distant as 1000 kilometers (600 miles) from the site. The mercury deposition measured in the Steubenville study was limited to wet deposition, that is, mercury dissolved in rainwater or snowfall. EPRI computer simulations (models) have also shown that power plants contribute about 65% of the mercury in rainfall at this location.

For several reasons, the findings at Steubenville cannot be generalized to the rest of Ohio, or to other parts of the United States. The Steubenville site was originally chosen by EPA because it is located among a large number of mercury-emitting sources, including smelters, incinerators, and power plants. The sources in the region are not only relatively high mercury emitters but they also release high proportions of oxidized mercury, which is more likely to deposit via rain or snowfall. Unlike Steubenville, most locations in the U.S. are at greater distances from mercury sources, and many of those sources emit primarily elemental mercury, most of which becomes part of the global mercury cycle with little impact on deposition within the U.S.

The Steubenville researchers also note that much of the mercury deposited there arrives in storm-front winds preceding the passage of large hurricanes to the east of the site. Very little of the U.S. is impacted by such wind patterns. The study results in Steubenville, therefore, are unlikely to apply elsewhere in the country.

Because Steubenville is unique in many ways, the findings at this location must be understood in that context. There has been some misunderstanding of the results as implicating only local sources of coal combustion as the primary contributors to mercury deposition. Local sources are typically defined as within 50 kilometers whereas this study is referring to sources within 1000 kilometers. Thus control of truly local sources – out to 50 or even 100 miles – are likely to have only a modest effect on mercury deposition in the area and result in only a modest benefit to public health.

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