Mercury …. A Public Concern

including

Analysis of Mercury Emissions from Coal-Fired Power Plants and Canada-Wide Standards

Prepared for Environment Canada

by

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March 2002

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Executive Summary

Mercury is one of the most toxic pervasive substances known. Its harmful effects on human health and the environment along with its increasing levels globally since industrialization have placed mercury as a priority issue that needs not only discussion and research but also resolution and action on a national and international scale.

The selection of the focus of this document, coal-fired plants in Canada, their mercury emissions and Canada-wide standards, has presented many challenges reflective of the nature of the industry and the substance itself. The choice was purposely made to not be limited to the confines of mercury emissions from the stack of coal-fired plants in isolation of the health and environmental considerations and energy-related issues. Consequently, this endeavor has elicited an expansive view of the subject matter.

The views and opinions expressed and the recommendations are those of the author and are reflective of the environmental community in Canada. Many of the chapters repeat similar themes intentionally, as the document is written to heighten public awareness on mercury and coal-fired plants and for dissemination in part or whole to a broad audience that includes governments, educational institutes and industrial sectors.

The intensity and effort that this project has engendered may best be described as stemming from the persistence of mercury, the obstinance of industry, the hesitancy of government action, and the authors' determination to overcome these obstacles.

The underlying message is the need for effective government measures that result in significant reductions of releases of mercury from coal-fired plants and other anthropogenic sources of mercury and to address the prevention of such releases of mercury in the first place in the best interests of public health and the environment.

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1 Introduction

1.1 Purpose

This document is designed to heighten public awareness on mercury and coal-fired plants in Canada – one of the most toxic substances prevalent in the environment. It is intended for public dissemination in part or whole to a broad range of audiences.

While the prevailing theme is the protection of human health and environment, its focus is primarily directed to atmospheric mercury emissions from coal-fired plants in Canada and efforts to reduce these emissions, in particular, Canada-wide Standards (CWS). These facilities have come under scrutiny both in Canada and the U.S. as a major contributor to anthropogenic atmospheric mercury emissions. The unfolding tableau of proposals and potential approvals of "new" coal plants as electrical energy sources gives further credence to the need to implement measures that prevent and significantly reduce mercury emissions from these facilities forthwith.

The material is written from the perspective of the environmental community in Canada, specifically, Environmental Non-Government Organizations (ENGOs). It is intended to enhance the value and contribution of the ENGO community towards advancing the process and progress of setting mercury CWS for this sector in a timely manner as well as support related endeavors currently underway nationally and internationally on mercury.

1.2 Scope and Context

The preparation of this document has entailed research into numerous mercury-related topics, particularly the health and environmental effects of mercury; the search for and analysis of information on mercury emissions from coal-fired plants; and a review of current international policies and commitments on mercury. Many members of environmental organizations (ENGOs) have been consulted to review and critique some of the material.

The main text includes an overview of health, social and environmental issues; a summary of government initiatives and programs on mercury in Canada, in particular Canada-wide Standards (CWS) for mercury from coal-fired plants; a review of the U.S. regulatory action on mercury and coal-fired plants; an analysis of mercury emissions data and cumulative impacts from these facilities; and specific recommendations and strategies for Canada-wide Standards.

The appendix includes a compilation of stories and articles on mercury and coal-fired plants that have been written (some of which have been published) and presentations I have given as a result of my involvement in the CWS process over the last three years. The topics of these works range from personal stories, human health effects, case studies on methylmercury poisoning, the effects of mercury on fish and wildlife and fish advisories to stories on the formation of coal and its use as an energy source, and of course the CWS process itself.

Of particular importance to the focus of this work are the 1999 ENGO position paper on mercury CWS and coal-fired plants and the March 2002 "recommendation document" to Ministers on the same issue (Appendix C and D respectively).

It is hoped that the material is helpful and useful in many respects to the public, environmental and health organizations, governments, industry and politicians. It is also intended to encourage political will to act in the best interests of public health and environment in Canada.

1.3 Mercury - A Global Concern

Mercury is likely most familiar to many of us as the shiny liquid metal used to fill thermometers[1]. This fascinating metal, otherwise known as quicksilver, has influenced many disciplines and practices throughout history - from mythology, alchemy, and folklore to medicine, science, technology and as a catalyst in chemical processes. Its many applications run the gamut from items such as jewelry, hats and paints to thermometers, thermostats, fluorescent light tubes, mercury-vapour lamps, batteries and electrical switches. Mercury is found as a component in numerous compounds such as disinfectants, insecticides, fungicides, dental amalgam and vaccines.

Mercury, a natural element found in the earth's crust, is neither whimsical nor pleasant [2]. In fact, it is an indestructible, highly volatile and extremely toxic heavy liquid metal present in air, water, land and biota, cycling continuously in the environment. While volcanoes, erosion, forest fires and evaporation from oceans and lakes are natural sources of atmospheric mercury, a significant proportion of mercury emitted into the atmosphere from oceans, terrestrial and vegetation results from the anthropogenic releases of mercury to environmental media.

Since the onset of the industrial age, the total global atmospheric mercury burden has increased anywhere from 200% to 500%. Anthropogenic sources may account for at least 70% of the estimated 5000 tonnes of mercury emitted annually to the atmosphere[3]. The most significant anthropogenic sources of mercury include industrial operations that use or burn substances containing mercury such as smelters, incinerators, coal-fired generators, chlor-alkali facilities, and cement manufacturers. In addition, the widespread use and disposal of many products that contain mercury contributes to further releases of mercury to the environment. The influence of such activities have impacted and severely altered the natural mercury cycle in a relatively short time.

The increase in mercury in the environment has raised concern worldwide, particularly in areas where visible and pronounced long-lasting effects of mercury poisoning have occurred. However, the lack of reporting criteria of mercury emissions and the paucity of

[1] The chemical symbol for mercury, Hg, comes from the Latin word Hydrargyrum, meaning liquid silver.
[2] Mercury is naturally found in the earth's crust in the form of a reddish-coloured ore, known as cinnabar, mercuric sulphide.
[3] Mercury Case Study, " Meeting the Challenges of Continental Pollutant Pathways, North American Commission of Environmental Cooperation, March 1997

information worldwide may well imply that the total emissions of mercury to the environment are grossly understated.

Environmental and health agencies and governments around the world agree that mercury in air and water is a toxic pollutant that threatens humans and wildlife. What makes it particularly threatening to human health is that it can cause irreversible neurological damage, putting fetuses, infants, children and women of child-bearing age at risk and endangering the health of communities that rely on fish and wildlife as a natural food source and economic resource. Effects on wildlife include deformities, reproductive difficulties, impaired growth and development, behavioural abnormalities and even death. As an indication of the prevalence of mercury contamination, high levels of mercury are found in swordfish, shark, tuna and other marine life on the East Coast in Canada. Mercury levels are on the rise across the Arctic, from fish along the Mackenzie River to seabirds off Baffin Island and in the waters of Hudson Bay. Mercury is the most prevalent toxin found in large game fish in the Great Lakes. Loon populations are in decline in many waterbodies. Disturbing effects of mercury contamination have been observed in eagles, mink and other fish-eating animals. Most Canadian provinces and states in the U.S. issue advisories on fish consumption as a result of mercury levels found in many species of fish.

The typical mercury content of lakes has increased significantly, as much as seven-fold since industrialization. In the last decade alone, a noted increase in the level of mercury in rainfall has been demonstrated in the Great Lakes area [4]. Phenomena such as acid rain and warmer water temperatures favour an increase in mercury levels in water bodies and exacerbate the problem of increased mercury content in soils and lakes.

Given the public health and ecological consequences, governments are responsible to ensure that the public and especially those most at risk are effectively informed about and protected from the health risks associated with mercury exposure. In that respect, governments must ensure that freshwater and ocean fish are effectively monitored and tested for mercury and that the public are warned about the health risks from the consumption of contaminated fish. At the same time, governments bear responsibility to enact appropriate measures that result in significant reductions and elimination of the purposeful use and release of mercury to the environment.

The longer and more extensive the anthropogenic use and emissions of mercury continue, the greater the global loading and cumulative impact of mercury will be. Even if all new mercury releases would cease today, it would take at least 50 years before the fish would be safe to eat because of the pervasive nature of mercury. It is indeed tragic that a healthy and readily available food source such as fish may be completely wiped out from human diet and that wildlife is completely unprotected in this regard. The intentional use and anthropogenic release of mercury to the environment must be reduced and eliminated.

[4] National Wildlife Federation “Clean the Rain, Clean The Lakes”, September 1999

1.4 Mercury – A Persistent Poison

A Historical Perspective

Just as mercury is a fascinating and intriguing substance, so is its history, from its influential role in mythology and cultural practices to its many applications in alchemy, science, technology and medicine. Named after the fleet-footed Roman messenger of the gods, mercury was known to the ancient Chinese and Hindus and has been found in the Egyptian tombs of 1500 BC. Aristotle recorded its use in religious ceremonies in the fourth century BC [5].

In the European pandemic of the late 15th century, mercury was used for the treatment of syphilis. While it continued to be used medically for a variety of disorders and infectious diseases, by the late 19th century, its medicinal benefits were being disclaimed, as its toxicity was becoming evident[6].

The 19th century phrase, "mad as a hatter", gained notoriety through Lewis Carroll's "Alice in Wonderland". It was coined to describe the twitching and dementia common among hatters who rubbed mercuric nitrate into pelts in order to stiffen them for top hats.

Much lesser known was the exposure of lighthouse keepers to mercury. The keepers were tasked with the maintenance of the vast baths of mercury that were used to support the heavy rotating lenses of the lighthouses of the late 19th and early 20th centuries. Not only were they exposed to mercury through physical contact but also through inhaling its vapour[7]. The extent of the effect of this exposure on the keepers can only be surmised.

"Minamata Disease", synonymous with the large-scale methylmercury poisoning in Minamata, Japan in the 1950's, was caused by discharge of methylmercury from an acetaldehyde manufacturing plant into Minamata Bay[8]. The most widely publicized epidemic poisoning in history, "Minamata Disease" demonstrates the worst possible effects that extensive exposure that methylmercury can have on human health and the environment.

Today, the increased presence of mercury in the environment has become a major concern worldwide.

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[5] Gary Crittenden, Solid Waste and Recycling, Editorial "Mercury Rising"; February/March 2000

[6] K.A. Graeme and C.V. Pollack, Jr. Heavy Metal Toxicity, Part 1: Arsenic and Mercury, The Journal of Emergency Medicine, vol 15, no.1, pp.45-56, 1988

[7] The baths of mercury upon which the lenses floated contained as much as 250 kg of mercury. The keepers would drain off and strain the mercury and then replenish the baths. While no longer in use, mercury baths are still found in lighthouses. In 1999 Canada's lighthouses were cited as a potential hazard due to the levels of mercury.

[8] The production of acetaldehyde, a compound used in manufacturing fertilizers and plastics, requires the use of mercury as a catalyst. More information on "Minamata Disease" is found in Appendix B.

Forms of Mercury

Mercury can occur in 3 chemical forms, elemental, inorganic, and organic. ***Elemental mercury*** refers to the metallic element (Hg^0), also known as quicksilver or metallic mercury. In this form, mercury can exist as a shiny silver liquid or a colourless, odourless gas vapour at room temperature. ***Inorganic mercury*** (Hg^{1+} and Hg^{2+}) refers to mercury in combination with other elements such as sulphur, chlorine, and oxygen). ***Organic mercury*** refers to mercury compounds that include carbon, such as methylmercury (CH_3-Hg)[9]. Each of these forms exhibits unique characteristics chemically, biologically and has different degrees of toxicity.

Anthropogenic activities involving combustion sources, mining and smelting, and incineration generate primarily elemental mercury and to a lesser extent, inorganic mercury. Most of the mercury present in the atmosphere is elemental mercury, an extremely volatile form that can reside in the atmosphere as a gas anywhere from three months to two years. Approximately 60% of mercury emissions, in particular elemental mercury, tend to be transported far beyond their sources, resulting in elevated levels throughout North America at locations far from the source, such as the Arctic.

Some of the elemental mercury will also react with oxidants in the atmosphere and be transformed into inorganic mercury, a highly soluble form of mercury that unlike the elemental form, tends to be deposited locally. Through precipitation, inorganic mercury is deposited onto the soil, lakes and rivers. Once in water, mercury is transformed by bacterial action into methylmercury (CH_3-Hg), an organic form of mercury, and is subsequently absorbed by plankton. As larger aquatic organisms feed on the plankton, methylmercury concentrates in their tissues.

Methylmercury bioaccumulates through the food web in aquatic systems to such a degree that levels in predatory fish are thousands and millions of times greater than found in water. Top predator fish such as salmon, lake trout and walleye have mercury levels millions of times higher than levels found in surrounding waters[10].

1.5 Health and Environmental Effects

Effect on Human Health

Incidences of acute and chronic mercury poisoning in the workplace, home, and schools have occurred, primarily due to exposure resulting from maintenance, breakage and spills of mercury-containing instruments and equipment [11].

[9] Other organic forms include dimethylmercury, ethylmercury, and phenylmercury.
[10] Bioaccumulation or biomagnification describes the process by which lower organisms take up and store toxins such as mercury from their surroundings. Their predators collect and retain the toxins in their tissues, building up higher concentrations, and so on throughout the food chain, resulting in the highest members of the food chain having levels of methylmercury millions of times of that found in the surrounding waters.
[11] C. Taueg et al, Acute and Chronic Poisoning from Residential Exposure to Elemental Mercury, 1989-90, Clinical Toxicology, 30(1), 63-37 (1992) pp. 63-67

Large-scale incidences of acute mercury poisoning in humans as a consequence of industrial spills and discharges, and the use of mercury fungicides, have been documented [12]. Deeming such occurrences as "sporadic" or as "outbreaks" may convey a message that minimizes their importance. Yet these very incidences become the surrogate for "epidemiological studies" to determine "safe levels of exposure".

Regardless of whether metallic mercury is absorbed through the skin or inhaled into the lungs, it winds its way through the central nervous system to the brain leading to neurological disorders. Silent and sinister, mercury poisoning may not necessarily be recognized as such and can be easily misdiagnosed as a number of other diseases such as rheumatism, senile dementia, emotional instability and psychosis.

While all forms of mercury are dangerous if inhaled or ingested, organic mercury and in particular, methylmercury, the most common organic form of mercury and ***the most toxic form to living organisms***, is a potent neurotoxin and fetotoxin, easily absorbed orally and in turn easily enters the brain and fetus. Fish consumption is the predominant path of exposure to methylmercury for humans and fish-eating birds and mammals. Far removed from industrial activity, in the Arctic, as few as six steps in the food chain stand between methylmercury ingestion by microscopic organisms and consumption by human beings.

The first symptoms of methylmercury poisoning are loss of sensation at the extremities of the hands and feet and around the mouth, known as *paresthesia,* and loss of coordination, slurred speech, impaired vision and hearing, or *ataxia.* In severe cases of poisoning, blindness, coma and death may result. Prenatal exposure can lead to mental retardation and cerebral palsy. Symptoms of methylmercury poisoning may not appear until after a latent period of anywhere from weeks or months, possibly leading to misdiagnosis as indicated above.

While some "victims" of methylmercury poisoning may function at limited levels with disabilities, the underlying damage is irreversible. Not only is there the potential for long term effects of chronic exposure to various forms of mercury, there may well be complications arising from the synergistic impact of exposure to mercury and other toxic substances, such as PCBs.

While there is no scientific dispute about the hazards of high levels of mercury exposure, concern is emerging that even smaller exposures may cause subtle and irreversible damage to the brain and central nervous system, particularly among children and during fetal development. A recent study of the toxicological effects of methylmercury by the National Academy of Sciences (NAS) estimated that more than 60 000 babies born each year are at risk for neurological developments[13]. (More current data published by the Centers for Disease Control and Prevention (CDC) indicates that this estimate may be too low and that as many as 375 000 U.S. babies being born each year at risk[14].)

[12] Some of the documented cases are presented in Appendix B.
[13] Toxicological Effects of Methylmercury, National Research Council (NRC) of NAS, July 2000.
[14] National Health and Nutritional Survey (NHANES) Study published by the Centers for Disease Control and Prevention (CDC) March 21 2001

1.6 MERCURY – HUMAN HEALTH EFFECTS - FACT SHEET

The following table summarizes the range of effects of the three forms of mercury [15]:

Elemental Mercury	Inorganic Mercury	Organic Mercury
Significant hazard when inhaled. The central nervous system is highly sensitive to metallic mercury	The kidney is the crucial organ when ingested	Considered the most dangerous form – confirmed developmenta toxin, easily absorbed orally and enters brain and fetus. Most toxic in the CNS, kidneys and immune system also effected.
·1Increased heart rate and blood pressure ·2**Central nervous system**: cognitive, personality, sensory and motor disturbances; irritability, shyness, nervousness, emotional lability, memory loss; insomnia; Neuromuscular changes; vision and hearing disturbances; possible nerve damage and death; ·3Multiple sclerosis; ·4Possible links to chronic fatigue syndrome and Alzheimer's disease ·5Increased risk of spontaneous abortion and reproductive failure ·6Fatigue, fever, chills, elevated white blood cell count ·7Tremors, muscular pain ·8Skin rashes ·9Alteration of immune system function ·10 Kidney toxicity Stomatitus (inflammation of oral mucosa)	·1Highly irritating to the gastrointestinal tract, causing blisters and ulcers on the lips and tongue, and vomiting ·2Decreased urinary output and renal failure ·3Rashes and excessive perspiration; flushing of palms of hands and soles of feet ·4Irritability, weakness and muscle twitching ·5Elevated blood pressure	·6 Selective damage to developing brain ·7 Cerebral palsy, mental retardation (high doses) ·8 Paresthesia (loss of sensation at extremities - hands, feet and mouth) ·9 Ataxia (loss of coordination, impaired vision, hearing) ·10 Altered behaviour particularly in infants ·11 Neurological disturbances in adults include tingling, unsteadiness, irritability, abnormal reflexes ·12 Loss of consciousness, possible death ·13 Liver degeneration ·14 Abnormal heart rhythms, myocarditis ·15 Gastrointestinal disturbances- stomach inflammation, diarrhoea

[15] Physicians for Social Responsibility – Fact Sheet: Environmental Mercury Exposure and Human Health, 1997: and Lynn R. Goldman, MD, MPH; Michael W. Shannon, MD, MPH; Committee on Environmental Health, Technical Report, Mercury in the Environment: Implications for Pediatricians, Volume 108, #1, July 2001, pp 197 - 205

1.7 Impacts on Fish and Wildlife

Since fish absorb mercury from their food and water directly, they would in turn be susceptible to its adverse effects. Moreover, since mercury concentrations generally increase as the fish grows in size, the larger the fish, the higher the levels of mercury would be found in their tissues [16]. In fact, mercury exposure has been related to impaired sperm generation in guppies and high mortality among rainbow trout embryos.

The accumulation of mercury in fish populations has far-reaching effect on other species with wildlife at the high end of the food chain that feed off top predator fish most severely impacted. The effects manifest themselves in reproductive failure and behavioral abnormalities as well as damage to livers, kidneys and the central nervous system. Marine mammals (whales and seals), predatory birds (hawks and eagles) and predatory mammals are most vulnerable and consequently at risk [17]. Mercury has been noted to damage their livers, kidneys, and most particularly, the central nervous system of these animals with the most devastating effects in embryos and the young. It is the likely cause of reproductive failure, reduced survival and limited ability to fight off disease amongst loons, mallards, black ducks, eagles, mink, turtles, river otters, and other wildlife. It is suspected to be the cause of an increasing incidence of deformities among bullfrogs and northern leopard frogs [18].

1.8 Summary

Mercury poses a serious threat to every ecosystem, capable of impairing the central nervous system and the developing fetus. It is indestructible and persists in the environment for years. There are no known ways to safely eliminate or "retire" mercury.

Concentrations of methylmercury found in fish in many lakes and rivers have reached a level where consumption of fish poses threats to human health, fish and wildlife. Fish advisories are routinely issued to warn of the potential hazards of consuming certain fish species. Of particular concern are pregnant women, children, and communities where fish is a food staple, an economic resource and the predominant source of protein in the diet. While such advisories provide a modicum of protection, they cannot be the sole avenue or remedy to protect populations, in particular, the sensitive populations. All too often, the effects of mercury poisoning on fish and wildlife are ignored when perceived only through the human consumptive lens.

The increase in mercury levels globally serves as a powerful indicator of the disturbing influence and consequence of anthropogenic emissions of such toxic substances to the environment and the need to rein in and prevent these emissions.

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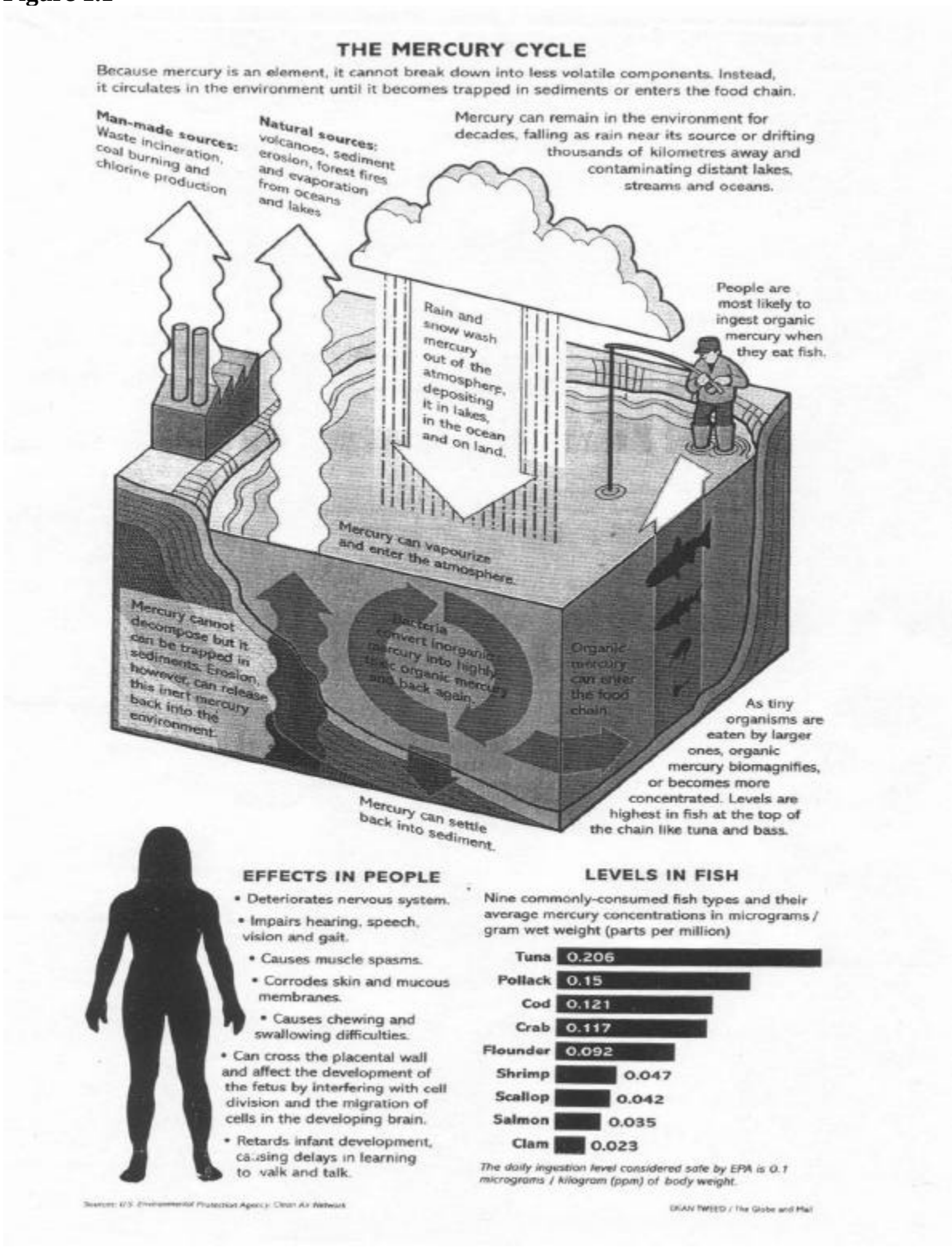
[16] Mercury contamination of the St. John River Food Chain – Report from Conservation Council of New Brunswick and Union of New Brunswick Indians, 2000.

[17] High mercury levels have been identified in free-roaming Florida panthers. Scientists now think that chronic exposure to mercury may be contributing to the extinction of these highly endangered animals.

[18] National Wildlife Federation, Great Lakes Natural Resource Center, www.nwf.org/greatlakes

Figure 1.1


THE MERCURY CYCLE
Because mercury is an element, it cannot break down into less volatile components. Instead, it circulates in the environment until it becomes trapped in sediments or enters the food chain.
Man-made sources: Waste incineration, coal burning and chlorine production
Natural sources: volcanoes, sediment erosion, forest fires and evaporation from oceans and lakes
Mercury can remain in the environment for decades, falling as rain near its source or drifting thousands of kilometres away and contaminating distant lakes, streams and oceans.
Rain and snow wash mercury out of the atmosphere, depositing it in lakes, in the ocean and on land.
People are most likely to ingest organic mercury when they eat fish.
Mercury can vapourize and enter the atmosphere.
Mercury cannot decompose but it can be trapped in sediments. Erosion, however, can release this inert mercury back into the environment.
Bacteria convert inorganic mercury into highly toxic organic mercury and back again.
Organic mercury can enter the food chain.
As tiny organisms are eaten by larger ones, organic mercury biomagnifies, or becomes more concentrated. Levels are highest in fish at the top of the chain like tuna and bass.
Mercury can settle back into sediment.
EFFECTS IN PEOPLE
• Deteriorates nervous system.
• Impairs hearing, speech, vision and gait.
• Causes muscle spasms.
• Corrodes skin and mucous membranes.
• Causes chewing and swallowing difficulties.
• Can cross the placental wall and affect the development of the fetus by interfering with cell division and the migration of cells in the developing brain.
• Retards infant development, causing delays in learning to walk and talk.
LEVELS IN FISH
Nine commonly-consumed fish types and their average mercury concentrations in micrograms / gram wet weight (parts per million)
Tuna 0.206
Pollack 0.15
Cod 0.121
Crab 0.117
Flounder 0.092
Shrimp 0.047
Scallop 0.042
Salmon 0.035
Clam 0.023
The daily ingestion level considered safe by EPA is 0.1 micrograms / kilogram (ppm) of body weight.
Source: U.S. Environmental Protection Agency; Clean Air Network
GRAN TWEED / The Globe and Mail

2 Government Programs - Mercury

2.1 Voluntary Measures and Regulation in Canada

Over the past several years, both federal and provincial governments have increasingly placed reliance on voluntary instruments rather than regulatory measures as a means for industries to report emissions, develop performance guidelines, pollution prevention strategies and the like. The Canadian Environmental Protection Act (CEPA) and the National Pollutant Release Inventory (NPRI) under CEPA are generally considered to represent the cornerstone of federal legislative action vis-à-vis mandatory requirements for reporting emissions and enabling regulation by many environmentalists.

For voluntary measures to be effective, there needs to be an underlying supporting regulatory framework that requires mandatory testing, reporting and monitoring in a manner that is "open and transparent". In the absence of a sound regulatory framework, "voluntary initiatives" enhanced or otherwise, can not be the prime instruments to achieve meaningful results in a timely fashion. In fact, Canada's Environmental Performance has come under criticism by the Organization for Economic Co-Operation and Development (OECD) recently who singled out our reliance on voluntary and poorly monitored accords, tax policies and severe spending cuts, all of which undermine the ability of Canada and the provinces to monitor and enforce existing laws[19].

In order to ensure the openness and public availability of information as well as achieve meaningful reductions in levels of pollutant substances, public interest groups (Non-Government Organizations, NGOs) and the public in general expect governments to adopt the appropriate regulations, enforcement and monitoring regimen to ensure commitment on the part of industry to comply with such regulations and commitment on the part of government that they are willing to apply legal measures to ensure compliance.

Regulations have been shown to be the strongest motivator for technological innovation and the development of strategies toward emissions reduction. For example, the progress in innovation and application of advances control technologies for NOx and SO_2 for the electricity sector in the US was driven by an environmental regulatory framework that established overall performance standards, emission targets and target dates without dictating the means to meet those targets[20].

Regulations also give industry a level of "certainty" as to what is acceptable and what must be achieved in a timely manner. The drive to improve their environmental performance beyond regulations and do better through voluntary initiatives and programs forms the basis of good public relations and illustrates corporate responsibility to what may be referred to as the "triple bottom line" – economy, community and environment.

[19] The Organization for Economic Co-Operation and Development (OECD) cited Canada's mismanagement of toxic materials, and water resources and on Canada's response to climate change (September 2000 – Toronto Star.

[20] Praveen K.Amar: Relationship between Environmental Regulation and Technology Innovation: Northeast States for Coordinated Air Use Management (NESCAUM) Report, Controlling Emissions from Coal-Fired Boilers September 2000. Progress in technology innovation and implementation control has not occurred (and will not occur) on its own, as long as the cost of controlling emissions is considered an externality to the cost of producing electricity.

Governments are expected to provide the necessary legislative tools to set standards, regulation and enforcement protocols. Furthermore, governments are expected to consult with various stakeholders including environmental and health organizations, aboriginal communities, local communities (and workers). They are also charged with disseminating information to the public and seeking ways to encourage and develop public awareness and education.

The record and results of voluntary initiatives to date illustrate the need to establish mandatory standards that will serve to enable setting appropriate targets and timelines that are enforceable and thereby reinforce Canada's commitment to reduce the anthropogenic use, generation and release of mercury. Voluntary non-binding agreements do not suffice.

2.2 Mercury and Coal-Fired Plants – Review of Domestic Programs

i) The Strategic Options Process – Electric Power Generation Sector

The Strategic Options Process (SOP) was a multi-stakeholder consultative sectorial approach established for the purpose of preparing recommendations on the management of toxic substances as defined by the first Priority Substance List (PSL 1) under the Canadian Environment Protection Act (CEPA). Mercury is one of these substances. The Electric Power Generation (Fossil Fuel) Sector was identified as one for which the SOP was appropriate.

From its onset in 1995 throughout its lifespan of about 2 years, the SOP was unable to resolve fundamental disagreements amongst stakeholders and did not result in any substantive measures. Notably, mercury was excluded from consideration of management options and required further research because of uncertainties regarding the extent to which mercury emissions from the EPG sector may pose a risk to health and environment, and because no demonstrated add-on technological control systems for mercury were available [21].

ii) Canadian Environmental Protection Act (CEPA)

Under the Canadian Environment Protection Act, (CEPA), mercury is designated as Track 1I substance, requiring life cycle management to prevent or minimize its release into the environment[22].

As of 2000, the National Pollutant Release Inventory (NPRI) under CEPA requires mandatory reporting of releases and transfers for facilities manufacturing, processing and otherwise using more than 5 kilograms of mercury annually.

[21] Strategic Options for the Management of Toxic Substances Electric Power Generation (Fossil Fuel) Sector -Report on Stakeholder Consultations, April 1997

[22] The revised CEPA '99 requires Environment Canada to have a national inventory of releases and pollutants and requires Environment Canada to publish the inventory. If facilities meet the reporting criteria, they report to the National Pollutant Release Inventory (NPRI).

iii) Canada Wide Standards (CWS) for Mercury

Under the Harmonization Accord and the Standards Sub-Agreement, the Canadian Council of Ministers of the Environment (CCME) has committed to developing and implementing Canada-wide Standards (CWS) for a number of substances that are of national concern to human health and/or the environment. Mercury has been selected as one of the priority substances. Stakeholder participation and NGO representation are key components of the Accord.

The CWS process for mercury has focused on atmospheric releases from designated sectors that account for most of such releases. These sectors include base metal smelters, waste incineration (including medical, municipal solid waste, and hazardous waste), coal-fired electrical power generators (EPG), and products containing mercury. To date, CWSs have been endorsed for smelters and incinerators[23].

iv) Multi-Pollutant Emission Reduction Strategy (MERS)

"MERS", under the auspices of CCME, is a relatively new process that emerged in 2000 as a means of seeking a strategic multi-pollutant approach to reduce emissions from the EPG (fossil fuel) sector. While the focus of MERS is placed on meeting the PM and Ozone CWS standard and complimenting a CWS for mercury from coal-fired plants, at the same time, MERS is to pursue integrated solutions to address other air issues such as acid rain, climate change and air toxics [24].

A key element in the MERS process is the collection and analysis of information on several topics incorporated into a Clean Air Workbook to serve as background material for jurisdictions. The result of the information gathering and consultations is the drafting of jurisdictional plans in 2002 followed by a national "roll-up" in 2003 of actions across all jurisdictions to reduce emissions from the EPG sector [25].

The process has encountered many difficulties and while the concept is generally supported, many of the ENGOs that have participated in the process fear that MERS may be yet another process with questionable results. The ENGOs have advocated support for regulation of the four main pollutants, namely SO_2, NOx, CO_2 and mercury as the means towards validating MERS.

v) Canada-Ontario Agreement (COA)

The COA (1994) lies under the Great Lakes Water Quality Agreement (1987). Specifically with respect to mercury, the COA is undertaking pollution prevention program with hospitals and dentists and is improving the mercury release inventory from several sources.

2.3 Regulatory Action in the United States

[23] The Chloralkali industry has eliminated mercury from its process by adopting a process that replaces mercury use.
[24] The CWS for PM and ozone has set ambient limits for $PM_{2.5}$ at 30 micrograms/m3 and Ozone at 65 parts per billion to be attained by 2010.
[25] The MERS process has held two national consultations in 2001. Material is available from the CCME.

The United States Environment Protection Agency (US EPA) will be regulating mercury emissions from coal-fired plants, the largest source of such emissions in the United States. The draft regulation is due 2003 and the final rule by 2004[26], with compliance by all units by 2007. ***Posting of mercury emissions from every coal-fired plant in the country is required along with detailed information on coal.*** Furthermore, US law will require other mercury sources to report their emissions of mercury and to strengthen regulatory restrictions to reduce the total human-caused mercury emissions nationwide by 50% from 1990 levels by 2006.

2.4 International Commitments

Concern regarding the large increase in mercury levels globally and its implications on human health and the environment and its implications for human health and the environment has led to a number of initiatives and programs on an international scale. Canada has assumed obligations and commitments to reduce mercury emissions in the following agreements:

- The 1997 Great Lakes Binational Toxics Strategy (BNS), an agreement between Canada and United States[27], establishes a process to work toward ***virtual elimination*** [28] of specific persistent bioaccumulative toxic substances, including mercury, from the Great Lakes Basin. The Canadian goal was to seek a 90% reduction in the use, generation, or release of mercury by the year 2000 in the Great Lakes Basin. The US goal sought a 50% reduction by the year 2006 for all land-use based sources.

- The Mercury Action Plan adopted in 1998 by the Eastern Canadian Provinces and New England Governors states as its goal the virtual elimination of anthropogenic mercury in the region. The Plan calls for regional reductions in mercury emissions from identified sources that would achieve a 75% reduction in emissions by 2003. Specifically, a 60-90% reduction is being sought from coal-fired plants by 2010. In addition, the plan incorporates monitoring, research, reporting, education and recycling programs.

- The1998 UN ECE Long-Range Transboundary Air Pollution Heavy Metals Protocol relating to mercury, cadmium and lead, signed and ratified by Canada, and legally binding, is seeking 50% reduction from 1990 emission levels 8 years from ratification

[26] The decision to regulate mercury emissions from coal-fired plants was announced December 2000. The EPA will issue its final rule by 2004 under section 112 of the Clean Air Act. Chapter 6 of this document provides more detail and background on the decision.
[27] The Strategy is in keeping with the objectives of the 1987 Great Lakes Water Quality Agreement (GLWQA).
[28] **Virtual elimination** as articulated by the International Joint Commission refers to **use, generation and release** of such substances by encouraging and implementing strategies consistent with the philosophy of zero discharge.

and the use of Best Available Techniq ues (BAT) [29]. At its 21st session (February 5-9, 2001), the Governing Council (GC) of the United Nations Environment Programme (UNEP) agreed to the undertaking of a global assessment of mercury and its compounds, including any relevant options for international action. The report and recommendations will be considered at its 22nd session in 2003.

- The Commission for Environmental Cooperation North American Regional Action Plan for Mercury was signed by Canada June 2000. It has established as its goal the reduction of mercury to approach natural levels and fluxes in certain environmental media, seeking a 50% reduction in mercury emissions by 2006.

- Arctic Environmental Protection Strategy – developed by 8 circumpolar nations, the Nation Arctic Council Northern Contaminants Program establishes mercury as well as POPs as a serious health concern for the North, issues the Barrow Declaration October 2000 calling for UNEP global assessment

2.5 Summary - Pulling the Pieces Together

The myriad of mercury-related programs in Canada and the U.S. as well as worldwide is staggering. As an illustration of the complexity of these initiatives and their relationship, a rather complicated "flow- chart" of these programs with their particular connection to coal-fired plants is attached at the end of this chapter [30].

With all these activities, some progress would be expected in addressing domestic and global mercury issues. It would be a formidable task to evaluate the effectiveness of these initiatives. Rather, it may be more fruitful to assess our own progress and seek the benefits of action earlier rather than later in consideration of a substance as toxic, persistent, and bioaccumulative as mercury. It would be hoped that Canada, as a receptor of mercury, would play a pivotal role and set an example by implementing strong measures at the home front, particularly from a sector that is likely to grow.

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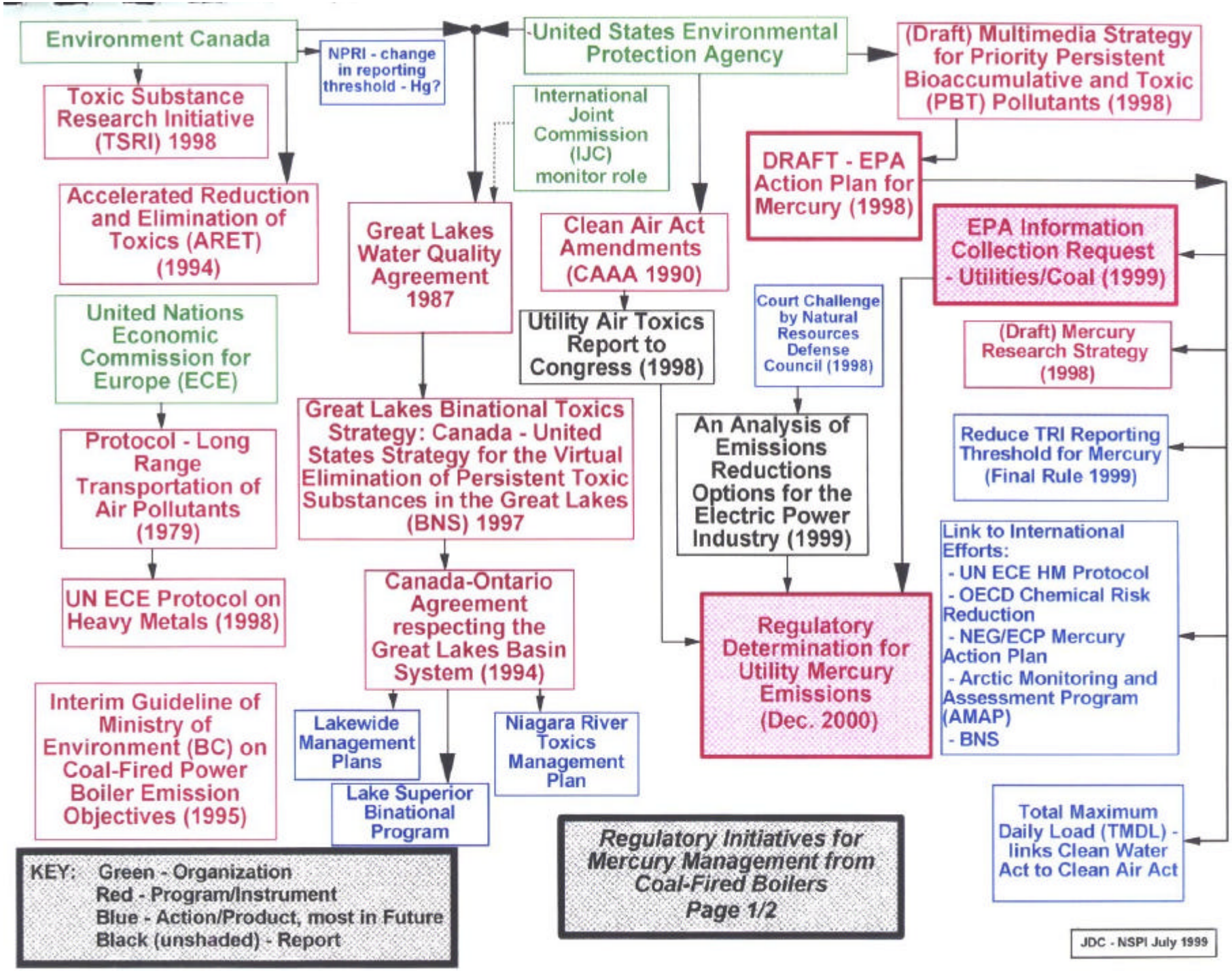
[29] *Best Available Techniques for Pollution Prevention and Control* (BAT) is defined by the European Commission as "the most effective and advances stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent, and where that is not practicable, generally to reduce emissions and the impact on the environment as a whole."

[30] The flow-chart (by Nova Scotia Power) was handed out at a CWS meeting in 1999.

One factor - one piece in the “flow-chart” is notably absent – and that is public education. If more emphasis would be placed in that arena, and more people were to know about mercury and its impact on human health and the environment, then perhaps there may actually be definite action taken to reducing anthropogenic emissions of mercury in a meaningful way.


Environment Canada
NPRI - change in reporting threshold - Hg?
United States Environmental Protection Agency
(Draft) Multimedia Strategy for Priority Persistent Bioaccumulative and Toxic (PBT) Pollutants (1998)
Toxic Substance Research Initiative (TSRI) 1998
International Joint Commission (IJC) monitor role
DRAFT - EPA Action Plan for Mercury (1998)
Accelerated Reduction and Elimination of Toxics (ARET) (1994)
Great Lakes Water Quality Agreement 1987
Clean Air Act Amendments (CAAA 1990)
EPA Information Collection Request - Utilities/Coal (1999)
United Nations Economic Commission for Europe (ECE)
Utility Air Toxics Report to Congress (1998)
Court Challenge by Natural Resources Defense Council (1998)
(Draft) Mercury Research Strategy (1998)
Protocol - Long Range Transportation of Air Pollutants (1979)
Great Lakes Binational Toxics Strategy: Canada - United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes (BNS) 1997
An Analysis of Emissions Reductions Options for the Electric Power Industry (1999)
Reduce TRI Reporting Threshold for Mercury (Final Rule 1999)
UN ECE Protocol on Heavy Metals (1998)
Canada-Ontario Agreement respecting the Great Lakes Basin System (1994)
Regulatory Determination for Utility Mercury Emissions (Dec. 2000)
Link to International Efforts:
- UN ECE HM Protocol
- OECD Chemical Risk Reduction
- NEG/ECP Mercury Action Plan
- Arctic Monitoring and Assessment Program (AMAP)
- BNS
Interim Guideline of Ministry of Environment (BC) on Coal-Fired Power Boiler Emission Objectives (1995)
Lakewide Management Plans
Niagara River Toxics Management Plan
Lake Superior Binational Program
Total Maximum Daily Load (TMDL) - links Clean Water Act to Clean Air Act
KEY: Green - Organization
Red - Program/Instrument
Blue - Action/Product, most in Future
Black (unshaded) - Report
Regulatory Initiatives for Mercury Management from Coal-Fired Boilers
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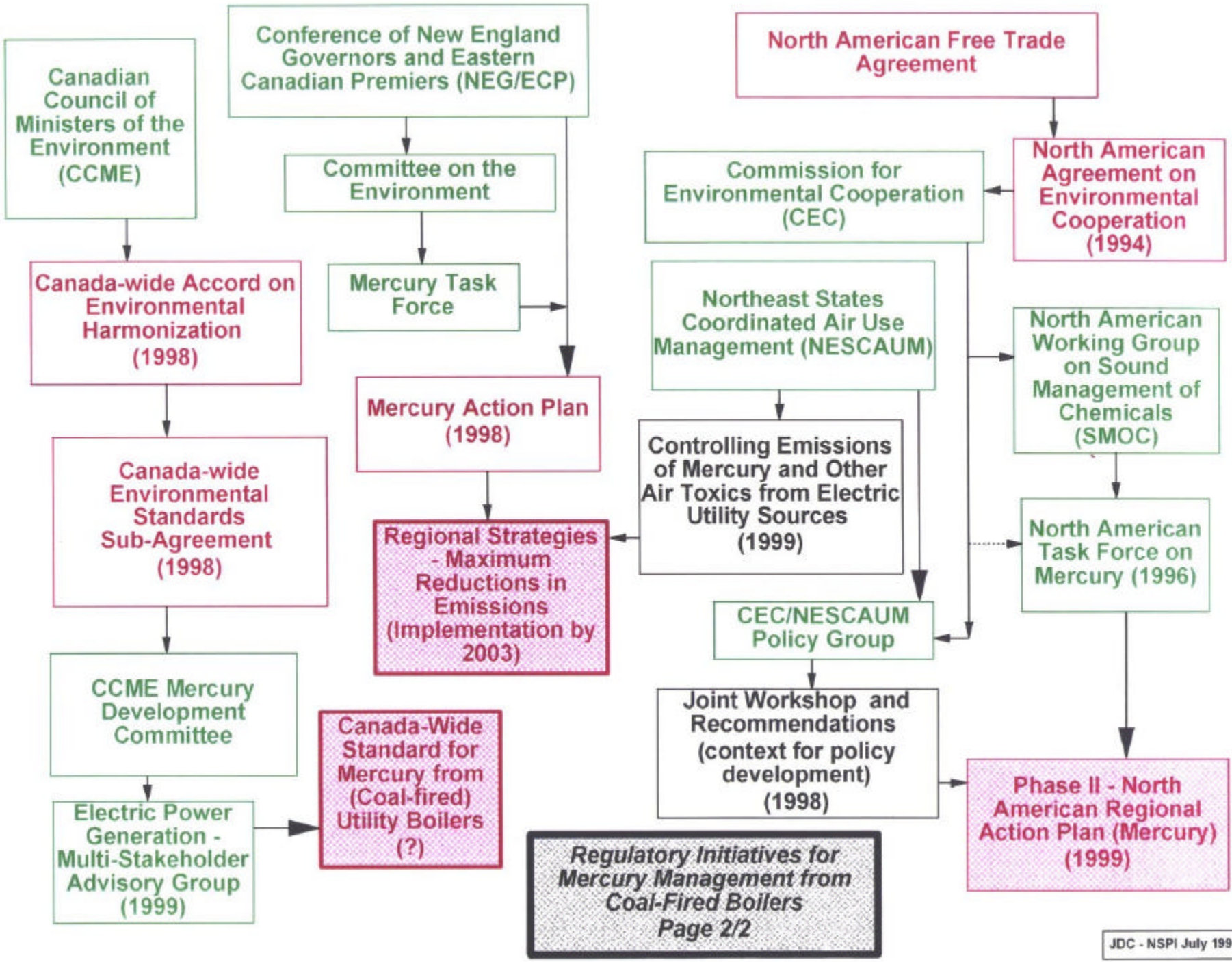

Canadian Council of Ministers of the Environment (CCME)
Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP)
Committee on the Environment
Mercury Task Force
Canada-wide Accord on Environmental Harmonization (1998)
Mercury Action Plan (1998)
Canada-wide Environmental Standards Sub-Agreement (1998)
Regional Strategies - Maximum Reductions in Emissions (Implementation by 2003)
CCME Mercury Development Committee
Canada-Wide Standard for Mercury from (Coal-fired) Utility Boilers (?)
Electric Power Generation - Multi-Stakeholder Advisory Group (1999)
North American Free Trade Agreement
North American Agreement on Environmental Cooperation (1994)
Commission for Environmental Cooperation (CEC)
Northeast States Coordinated Air Use Management (NESCAUM)
North American Working Group on Sound Management of Chemicals (SMOC)
Controlling Emissions of Mercury and Other Air Toxics from Electric Utility Sources (1999)
North American Task Force on Mercury (1996)
CEC/NESCAUM Policy Group
Joint Workshop and Recommendations (context for policy development) (1998)
Phase II - North American Regional Action Plan (Mercury) (1999)
Regulatory Initiatives for Mercury Management from Coal-Fired Boilers
Page 2/2
JDC - NSPI July 1999

3 Canada-wide Standards for Mercury – Electric Power Generating Sector

3.1 Background

The development of Canada-wide Standards (CWSs) was initiated by the Canadian Council of Ministers of the Environment (CCME) under the Harmonization Accord on the Environment (January 1998). Governments committed to developing and implementing Canada-wide Standards for substances considered of national concern to human health and the environment. "Development Committees" composed of government representatives have been established to guide this process and develop recommendations for standards. Stakeholder consultation and participation from non-government organizations (NGOs) are a required integral component of the process to give advice and feedback to the development committees.

CWSs are intended to be achievable targets based on science, social and economic impacts and technical feasibility. They have no legal force and represent but one route for developing standards. Each government is responsible for the implementation of the standards in their jurisdiction and for the mechanism chosen to do so.

Six substances, including mercury, have been selected as priorities for the development of standards. The CWS process for mercury is being approached through sectors that were selected on the basis of being the major mercury emitters in Canada. These sectors are base metal smelters, incinerators, coal-fired electrical power plants and manufacturers and users of products that contain mercury.

At the onset of the CWS process, the over-arching principle articulated was as follows:

"The objective of developing and implementing Canada-wide standards for mercury is to improve the likelihood that Canadians can consume more fish containing less mercury, and to lessen the ecosystem threat posed by mercury."

This statement did little to reflect the serious nature of the mercury issue and was totally inappropriate as an overarching goal for governments.

Several other problems within the process surfaced immediately, not the least being the goals and principles and the inequitable participation granted to non-government groups. Further "difficulties" arose from industry representatives of the coal-fired electric power sector who challenged the accuracy of the data presented on mercury emissions while at the same time displaying a characteristic reluctance to provide necessary information.

As a stakeholder in this process representing environmental organizations, I have taken on a strong advocacy position in seeking to achieve meaningful standards and timely reductions in mercury emissions from coal-fired plants. I have sought to publicize the mercury story in the hopes that pressure from various sectors of the public will influence the process and government to act in the interests of the public good.

3.2 Annotated Chronology and Highlights of Mercury Meetings

To date, since the beginning of 1999, the Multi-stakeholder Group (MAG) for the Electric Power Generating Sector (EPG) has held several meetings, seven of which have been face-to-face sessions interspersed with teleconference calls.

Calgary (January 1999)
The introduction, or initiation rites to the CWS process, where the goals were stated, the consultant's data was rejected by industry, the NGOs protested and began to rewrite the goals. Followed this meeting, several teleconference calls were held. Most participants expressed dissatisfaction of the process, albeit for different reasons, and industry was silent on provision of information

Toronto (September 1999)
The NGO representatives in the multi-stakeholder advisory group (MAG) drafted a "position paper" calling for specific standards on mercury to be set for this sector, in preparation for presentation at the meeting of Environment Ministers in November. At the end of the meeting, in less than a day, over 30 organizations endorsed the draft position paper. By November of that year, more than120 groups signed on to the position paper. Despite this overwhelming endorsement and nationwide publicity, the Ministers' meeting was disappointing and without substance in this issue.

Winnipeg (March 2000)
For the first time, at the end of the meeting, the industry association representative handed out "data, as requested". The "data" was nothing more than a combination of verbal commentary, little information other than convoluted ranges of values for mercury concentration in coal which were very difficult if not impossible to interpret, complete inconsistency across the board in what little information was provided, and a lot of blanks. The futility of this exercise became all the more apparent when any attempt to write a written review of the outcome evolved into a farcical one-act-play titled "Memorable Moments in Mercury Meetings".

Halifax (December 2000)
This was a brief meeting of little consequence and no action. The government presented scenarios – but no standards. The new initiative, Multi-Pollutant Emissions Reduction Strategy (MERS) was introduced. The representative from the Northeast States for Coordinated Air Use Management (NESCAUM) gave an inspiring talk on impact on regulation and its the catalytic effect on the development of new control technology and their declining cost.

Ottawa (January 2001)
Preceding an in-depth sessions on MERS for EPG, the brief mercury meeting revealed that the mercury emissions data to date severely underestimated the mercury emissions and that new coal plants were being proposed – contrary to any assumptions by the group that no new plants were planned in the foreseeable future. The EPA representative discussed their new mercury ruling.

Edmonton (June 2001)
ENGO presentation on expectations of process, the nature of accumulation of emissions over a long period (i.e., 20 years, lifetime of plant) and the beginning of the development of an NGO-Recommended Strategy for Governments for setting the CWS.
Discussion of scenarios ensued. No further data was received from industry.

Fredericton (September 2001)
Further hampered by resistance to provide information, the inconsistency between what is expected of utilities in the U.S. and the resistance by their counterparts in Canada to do likewise. The ENGO presentation included homework assignments for industry to provide the mercury and generation information by specific deadlines, a recommendation for standard setting and timetable, a new standard proposal.

Ottawa (November 2001)
Following a rather volatile session on MERS for EPG, a one-day mercury meeting was held. The frustration of lack of action was overwhelming. While much discussion was spent on the U.S. regulation and its possible implications for Canada, in the absence of a presentation of a CWS draft standard, once more, the ENGOs presented a renewed draft document on Recommendations for Standards, with details on the overall objective of achieving a 90% reduction in emissions by 2010. The document advanced specific mercury emissions standards for new and existing plants, a monitoring and reporting protocol and a review process.

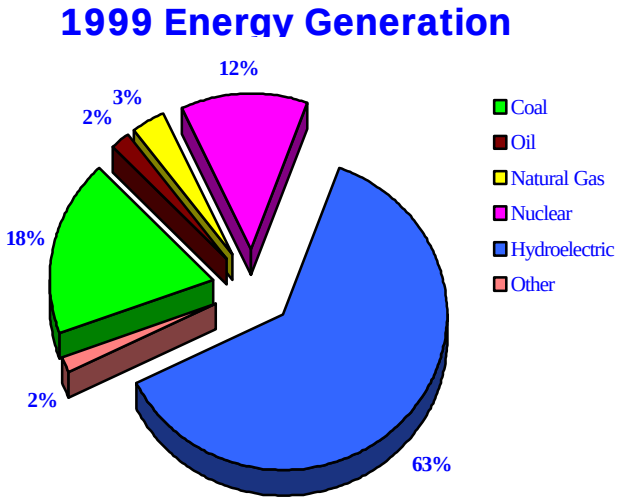
It is unlikely that there will be further meetings of the MAG. The CCME is due to meet in May 2002 to discuss (and sign on) to a standard. At this stage, they have some choices, but from the ENGO point of view – they can put teeth into the standard and adopt “in principle” the recommendations made by the ENGOs in part or whole and set the stage for a real progressive change in this industry.

The next section gives an overview of this industry from an ENGO perspective.

3.2 Coal-Fired Electric Generators – A Public Concern

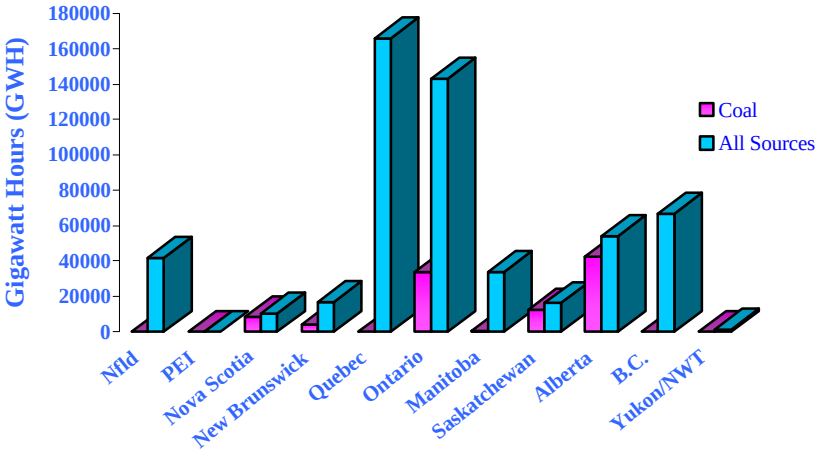
Note: This section is modified from the original submissions by the author to the Mercury CWS Multi-Stakeholder Advisory Group, September 1999 to take into account events that have transpired since that time. It surveys the use of coal as an electricity source in Canada along with the issues including a multi-pollutant approach, pollution prevention, controls and economic considerations.

The extent to which coal is used as a source of generation of electricity in Canada today is generally not widely recognized by many Canadians. While hydroelectric facilities comprise more than 50% of the sources of electricity, coal-fired plants generate about 18% of the total electricity in Canada. Renewable sources such as wind and solar power barely register as energy sources.



Looking at the provincial picture, coal-fired plants represent 24% of the electricity generated in Ontario and approximately 84% in Alberta[31]. In B.C. and Quebec, over 92% of power is generated by hydroelectricity[32].

Electrical Energy Generation in Canada by Province: Comparison of Coal to All Sources - 1999



[31] External Relations, Alberta Department of Energy "Alberta – a world energy center" July 2001

[32] Sources on generation: Electric Power in Canada, 1997, Canadian Electricity Association, Natural Resources Canada; Ontario Ministry of the Environment, "Coal-Fired Electricity Generation in Ontario" March 2001; Mercury Emissions Profile, A. Tilman

Coal-fired plants, evocative of the industrial era of the past, are well known for emitters of some of the worst air pollutants. Yet, in spite of this, in Canada in 1997, over 50 million tonnes of coal are burned every year to generate electricity[33]. What is even more disturbing, is that coal-fired plants are poised to be an expanding industry in the twenty first century in order to meet the unabated energy needs of North America with a "cheap" source of power.

The burning of coal leads to the emission of numerous hazardous air pollutants. These emissions are the primary components of acid rain and smog and a contributing factor to climate change. They are a major source of fine particles that can cause respiratory problems and premature mortality. Some of these substances, such as mercury, are neurotoxic and fetotoxic and persist in the environment for decades. A number of the other hazardous air pollutants, including arsenic and cadmium, are known carcinogens.

Reduced reproduction levels, neurological deficiencies and other effects observed in birds and mammals can be linked to the toxic pollutants emitted in the air that are deposited on land and in water, accumulating up the food chain. The capacity of many water bodies to sustain the qualities with which they are attributed is being diminished.

The extent of the cumulative impact and the heavy burden that such facilities exert on the quality of air, land, and water and on human health and wildlife may not be easily quantified, but the damage that is witnessed today could be only the tip of the iceberg.

Coal-fired Plants and Mercury

Levels of mercury in the environment have increased dramatically over the last 100 years placing vulnerable populations and wildlife are being placed at increased risk of exposure. Of primary concern is the transport and eventual deposition of airborne mercury, its persistence in the environment and its transformation into methylmercury, a highly toxic form that bioaccumulates in the aquatic food chain.

Of further concern is the role of coal-fired plants as a major contributing source of mercury releases into the environment and the likelihood that this role will continue in the absence of policies directed to curb these emissions.

Fossil fuels, primarily coal and oil, contain trace amounts of mercury. Coal, the fossil fuel most utilized in Canada for generation of electricity, contains the highest amount of mercury. Since mercury is an element, it is indestructible and cannot magically vanish. Accordingly, the amount of mercury in coal prior to combustion should equate with the amount of mercury released into the environment after combustion – whether it is in air, deposited in landfill or utilized in some way. Even if it may not be possible to trace the path that mercury follows from its specific source to a specific destination, once emitted into the atmosphere, mercury will travel and eventually be deposited on land and in water bodies, be it within 100 kilometers from a power plant, 1000 kilometers, or beyond[34].

[33] Electric Power in Canada, 1997, Canadian Electricity Association, Natural Resources Canada, pp. 56, 57

[34] It is estimated that up to10% of mercury emissions from coal-fired plants lie within 100 kilometers from the specific plant, 50% within 1000 kilometers of the facility and the rest, much further afield. (EPRI)

The mercury typically emitted from coal-fired plants is of both the elemental and ionic form, depending on the type of coal burned and other characteristics and controls in place. Ionic mercury tends to be deposited locally, within about 50 kilometers of its point of origin[35], whereas elemental mercury travels further afield. As a result, effects of these emissions have both local and long-range impacts.

Given the risks to public health and the environment, there can be no further delay in taking steps to reduce mercury emissions from coal-fired plants. Lack of action by governments and industry will guarantee increased mercury contamination for generations.

Information gaps

Mercury is a public health issue. The public has the right to know what pollutants are being emitted into the air, land and water, to what degree, the effects of these pollutants on their health and environment and the efforts being made to reduce such emissions.

Considerable debate wages as to the accuracy, reliability and accessibility of data in the Electric Power Generating Sector in Canada. Surely the onus lies squarely on industry to provide the requisite information and on government to ensure its collection and dissemination in the public forum. Further, such information must be readily accessible, verifiable and reflect the operating conditions of these facilities.

The data must be able to provide a complete account of mercury – from the input as determined by the content of mercury in coal to the output, the releases to the environment as a whole. Measurements, monitoring and mandatory public reporting of stack emissions and other information must occur on a consistent periodic basis.

In this respect, the data should include:

- Complete coal content analysis: the concentration and amount of mercury in the coal feed;
- The amount of mercury captured and subsequently disposed in landfills or otherwise used in byproducts in addition to the amount emitted into the atmosphere;
- The “mass of pollutant” emitted per quantity of useful output of energy. (In the case of mercury emissions from coal-fired plants, that would be the grams of mercury emitted /MWh generation).

[35] Ontario Ministry of the Environment, “Coal-Fired Electricity Generation in Ontario”, p.19, March 2001: in reference to the Lakeview Plant, which tends to produce a high proportion of ionic mercury.

It is expected that this data would be the basis for establishing a reliable numeric emissions baseline or reference for setting reduction scenarios and/or caps for Canadian coal-fired plants[36]. Further "refinement" of data by updated and improved methodologies should not deter or delay setting of goals and targets to achieve reductions of mercury emissions. In the absence of such data, the existing data and estimates from other years such as 1995 or 1999 could serve as an interim guideline.

Pollution Control OR Pollution Prevention – Mixed Metaphors

All too often, pollution prevention is interpreted as pollution control – technological add-on devices that maintain the status quo of sources of electricity while attempting to mitigate specific problematic emissions. The mere complexity of coal itself, coupled with the intrinsic and elusive nature of a substance such as mercury, is indeed a difficult challenge for the engineered solution. The ultimate folly of much of this control technological fix lies in its ultimate futility. To date, much effort has been placed in exploring control technologies in the context of end-of-pipe traditional approaches – that is, mitigation rather than prevention.

Methods available to reduce or eliminate mercury emissions include fuel-switching, coal cleaning, emission controls, improving efficiency, generating less electricity, and targeting dirtier plants. The chart below highlights some of the current more popular techniques used by coal-fired electrical generation plants to achieve SO_2 reduction along with the likely effects these controls have on emissions of other substances. The effectiveness of some of the technologies is related to the form of mercury emitted (ionic or elemental).

Method	**SO_2**	**NOx**	**GHG***	**Particulates**	**Mercury**
Switch to lower sulphur coal	lower	no effect	no effect	lower	no effect
Coal cleaning	lower	no effect	no effect	lower	some effect
In-furnace sorbent control	lower by (80-90%)	no effect	slight increase	lower	unknown (variable)
Scrubbers (FGD units)	Lower by (90-95%)	no effect	slight increase	lower	slight decrease (variable)
Switching to natural gas	**no emissions**	**lower**	**lower**	**no emissions**	**no emissions**

* Greenhouse Gases, mainly CO_2

A cursory glance at the chart shows that other than fuel switching to natural gas, such controls may have little, if any effect on reducing pollutants other than SO_2 and particulates.

[36] Such information was originally requested in order to set a standard by December 2000. However, despite continued "requests for information" *as of this date November 2001, such requests for information remain unanswered and/or publicly unavailable.*

Current technologies utilized by other sources to remove mercury have been more successful, demonstrating anywhere up to 95% effectiveness. Some of these control measures as well as other emerging technologies are being considered for electricity generators. These technologies include controls such as Carbon Filter Beds, Carbon Injection, Enhanced Wet Scrubbing, and Advanced Coal Cleaning. Reductions anywhere from 47% upward may be considered feasible through a variety of individual control technologies and combinations of controls [37].

Fuel-Switching to Natural Gas

The benefits of switching to natural gas compared to the application of some of the typical control technologies seem evident - no sulphur dioxide, mercury, and particulate emissions and lower NOx and Greenhouse Gases[38]. Fuel switching merits serious consideration as a preferred option suitable for certain facilities under certain conditions.

While fuel switching does significantly reduce emissions of many toxic substances "downstream", nonetheless it is an option that relies on fossil fuel consumption and in itself, can lead to other issues of concern upstream. Perhaps the advantage of fuel switching is best realized as a viable interim measure –not a panacea. This predicament will continue as long as the fossil fuel paradigm continues.

An Integrated Approach - Multi-Pollutant Strategy

Traditionally, environmental programs and standard-setting exercises have concentrated on single pollutants and their emissions. While emissions of some pollutants can be reduced using this approach, specific CO_2 capture incurs high costs, uncertain results, and often does not address other pollutants. Mercury controls are as yet unproven.

It may be more advantageous to explore the feasibility of applying multiple techniques and approaches simultaneously for a suite of pollutants rather than controls specifically directed to achieve reductions in mercury and SO_2 emissions. Emissions of CO_2, SO_2, NOx, mercury, particulates and other toxics emanate from the same sources. Investments in their prevention can have multiple benefits if planned properly.

This "multi-pollutant" strategy suggests the possibility of yielding synergistic benefits in a more effective and efficient manner as compared to single pollutant control strategies. But is this necessarily valid? Can the multiplicity of controls operate effectively without a driver – a pollutant whose reduction would ultimately reduce emissions of other substances? And what is the most appropriate driver OR would any one pollutant be the driver?

[37] Northeast States for Coordinated Air Use Management, (NESCAUM) pp. 5-7 March 1999). According to the Senes Report, Carbon Filter Beds, and a combination of Dry Sorbent Injection, Activated Carbon, and Wet Acid Scrubbing are most effective in lowering maximum stack concentrations. (Table 5.3, Senes Report 1999).

[38] According to a report by Toronto Public Health, 1999, air emissions of mercury and other persistent toxins from Ontario's electrical sector could be reduced by 78% by 2002 by shifting about 80% of coal-fired generation to natural gas, resulting in less emissions of mercury, sulphur, etc. within a shorter time frame.

In most situations, when Greenhouse Gas emissions are prevented, other emissions drop dramatically. But the reality is, lower CO_2 (GHGs) emissions are best achieved through prevention – higher thermal efficiency, energy conservation, cleaner fuel selection, or non-fossil alternatives. Unfortunately, prevention gets little attention.

Controlling mercury emissions through "end-of-stack" emission devices is not the answer to the problems created by the emission of mercury into the atmosphere. The potential that the mercury captured through control technologies will be deposited elsewhere, such as landfills and contaminate another component of the environment presents yet another dilemma faced by the technological-fix approach.

Controls offer only temporary solutions and represent a singular vision and approach to reducing mercury emissions. In attempting to deal with a singular pollutant, it is possible that emissions of other pollutants may increase. Then again, the efficiency of energy generation is further compromised by the addition of more controls.

In January 2000, Governments in Canada embarked on MERS – a Multi-Pollutant Emissions Reduction Strategy for the Electric Power Generating Sector. It waits to be seen if this particular process appropriately addresses the concerns raised by the author or if it becomes yet another exercise without practical or tangible results. This comment reflects the lack of any fundamental change in the CWS process for this sector.

Complimentary Strategies – Options to Consider

The emissions of greenhouse gases sulphur dioxide and nitrogen oxides and toxins such as mercury from coal-fired plants signal the need to alter our ways – it cannot be business as usual. Strategies based on conservation of energy and efficiency, pollution prevention at source, life cycle analysis of materials and renewable resources need to be advocated and implemented at all levels. Such strategies should receive political, legislative and financial support to enable the necessary shift from reliance on fossil fuels to renewable energy sources. Viable options for energy generation both in the short term and long term do exist and must be pursued. Such strategies would incorporate some of the following:

- Conservation of energy - generation and consumption (present projections of energy requirements do not necessarily incorporate conservation strategies);
- Improved data, monitoring and reporting regimens;
- Development of complete emissions profiles;
- Public reporting and accountability;
- Comprehensive multi-pollutant emissions strategies;
- Enhanced energy efficiency at the plant (operations, transportation, distribution);
- Reduction of purposeful use of mercury from facilities (e.g., instruments, switches);
- Emphasis on and investment in complimentary and renewable energy resources;
- Requirement of "set-aside" targets that stipulate the per cent of energy that from renewable sources (e.g., wind, solar, biomass, geothermal); and
- Construction of smaller, local facilities using cogeneration;

Clearly, in considering the options that are available for energy generation and the harm that coal-fired plants do to the environment, the reliance on fossil fuels, in particular coal must be reduced and phased out.

Economic Considerations

Cost factors generally considered refer to **control costs** to reduce mercury and do not factor in environmental externalities, that is, avoided or damage costs nor the mutual benefits accrued by reduction of SO_2, NOx and particulates. Such control cost analyses (measured as $ per kg of mercury removed) indicate that shifting from coal-fired generation to natural gas (by replacing an existing plant with a new combined cycle natural gas plant, and/or replacing coal at an existing plant) incur significant costs that are viewed as prohibitive. As major capital investments are not favoured by deregulated industries, consideration of options other than those based on fossil fuel consumption are not usually explored or given due consideration. (Klein, 1998 and Diener Reports, 1998).

Back-end controls have often been shown to be less cost-effective than integrated pollution prevention measures, and sometimes generate other adverse effects. In fact, CO_2 capture is particularly costly and extremely difficult. Further, prolonging the life of aging plants could only serve to extend the longevity of GHG emissions. Another factor to consider is the degree and cumulative impact that the continuation of such sources of energy will exert on land and water issues and on public safety.

The cost of fuel switching depends on many assumptions that can significantly affect the calculated cost-effectiveness. Such assumptions include coal and natural gas prices, plant capacity and age, capacity factor, air pollution control devices, cost of new equipment, discount rates and emission credits (if relevant). On that note, a word of caution may be warranted [39]. Given that fuel switching removes multiple pollutants, allocating the entire cost to the removal of a single pollutant such as mercury is inappropriate. Dividing the cost by the total weight of all pollutants removed may provide a better measure of cost-effectiveness of fuel switching and lower the cost per kg of mercury removed[40].

[39] The continued reliance on fossil fuels embraces market strategies such as emissions trading and credits that is untested with implications not known. Unless there are built in mechanisms to ensure real reductions in emissions and declining caps, emissions trading could lead to shifting problems downstream, yet another example of environmental injustice.

[40] Northeast States for Coordinated Air Use Management (NESCAUM), p.61 March 1999.

3.3 Canada Wide Standards (CWS) for Mercury

CWS Mercury Position Paper presented by Environmental Non-Government Organizations (ENGOs), September 1999

This "position paper" was developed in response to the lack of progress in the Canada-wide Standards for Mercury with respect to Coal-Fired Plants. The paper includes a preamble that gives context to the process and the problems encountered and offers recommendation for goals and standards. It was widely circulated across Canada to environmental and health organizations, First Nations, and other organizations. Within a two-month campaign period, over 120 organizations representing tens of thousands of Canadians endorsed the position paper in its entirety. The full text of the position paper including the preamble, the complete list of organizations endorsing the paper and the accompanying media release is included in the Appendix (Part C).

The following excerpt of the position paper includes the overarching goal and standard.

ENGO Position Paper - Mercury CWS and the Electric Power Generating Sector
(drafted September, 1999)

Goals and Principles

The ultimate or overarching goal and supporting principles that establish the context for setting standards on mercury emissions must encompass the following considerations:

- Mercury in its various forms is a Persistent Bioaccumulative Toxin (PBT), exhibiting neurotoxicity and fetotoxicity, posing risks to susceptible populations, in particular the developing fetus, children, women of child-bearing age, native populations, in addition to plants and wildlife;
- anthropogenic emissions of mercury have increased globally two- to five-fold over the last century;
- the contamination of fish from methylmercury, the most toxic form of mercury, and other pollutants have deprived wildlife, communities, and human population in general from a valuable and readily available food source;
- the impact of chronic exposure to long term "low levels" of mercury are unknown;
- uncertainty to date precludes the establishment of a threshold or safe level of exposure, if indeed such a level exists;
- viable options presently exist and can be further developed that would result in the prevention of use, generation and anthropogenic release of mercury to the environment; and
- international and binational agreements in which Canada is an active participant are being sought to reduce and eliminate anthropogenic sources of mercury;

Therefore, the ENGO community supports as overarching goal the elimination of the use, generation and release of anthropogenic sources of mercury to the environment in order to protect the most vulnerable populations and species of the ecosystem for the present and future generations.

Standards for Emissions Reduction (EPG Sector)

It is recommended that:

Emissions of mercury from coal-fired plants be reduced by 50% by 2005 and further reduced by 90% in year 2010, using 1995 as an interim baseline year.

The baseline year of 1995 would be replaced by a new baseline year of 2000 if and only if the emissions determined by the data-gathering exercise are found to be less in that year.

This position paper has become the basis for finessing further recommendations on CWS for this sector. While there have been some modifications to the position paper since the time that the position paper was drafted and additional events that have compromised and delayed the CWS process itself, the ENGOs remain committed to the principle of seeking 90% reduction of these emissions in a timely manner.

4 Mercury Data from Coal-Fired Plants

4.1 Background

It has not been that simple a matter to determine mercury emissions from coal-fired plants in Canada. It has been more like a trial by fire. To date, data of any sort from this sector has been notably scant and not made readily available, not only to the public but government as well. Until recently (2001), many facilities did not report their mercury emissions, as it was not mandatory. With recent changes to the National Pollutant Release Inventory, that will change. As basic a quantity such as generation is not typically reported on an individual facility basis. The complexity of coal, mercury speciation, operational conditions, control devices, the expense entailed, proprietary rights and confidentiality agreements are often cited by industry as reasons for not providing information or reporting. Whenever any such emissions data are published by governments and other sources, the data are often challenged by the industry as not being accurate and therefore without merit.

It is unacceptable that industry is recalcitrant in its continual resistance to provide information that is essential to the development of appropriate standards and furthermore, it is inexcusable that governments have been all too silent and passive in this matter.

In Canada, up until the year 2000, facilities emitting less than 10 tonnes of mercury were not required to report their emissions to the National Pollutant Release Inventory (NPRI) and any such reporting of emissions has been on a voluntary basis. As of the year 2000, the NPRI revised its reporting threshold for releases of mercury to the environment from 10 tonnes to 5 kilograms. The result of this change is that there is now a mandatory reporting instrument that will capture releases and transfers of mercury from all coal-fired facilities in Canada[41].

In conjunction with this federal initiative, Ontario has set new emissions standards, regulations and public reporting procedures for the electric power-generating sector that includes a reporting threshold for mercury at 5 kilograms[42].

While these initiatives represent positive action that should considerably improve an otherwise incomplete mercury inventory, much more information concerning these facilities is required in order to establish standards and track the performance of these facilities with respect to emissions of mercury and other pollutants.

Furthermore, these databases do not require facilities to undertake direct measurements of emissions if the information is not already on hand. In the absence of actual measured data, emissions reported are most likely based on “emission factors”, hypothetical values

[41] The National Pollutant Release Inventory (NPRI), under the Canadian Environmental Protection Act (CEPA) is a publicly accessible, mandatory, national database initiated in 1993. Facilities are required to report releases and transfers of specified substances according to reporting criteria, such as thresholds.
[42] Ontario Regulation OR127/01

that project likely emissions[43]. While this approach may provide a general first order estimate for a facility, it is preferable to have measured data and a mechanism for data verification.

4.2 Summary of Existing Public Data on Mercury Emissions for the Electric Power Generating Sector - Canada

- 1990: 1255 kilograms (Pollution Data Branch, Environment Canada)

- 1995: estimated to be 1300-1400 kilograms[44] (presumably on the low side).

- 1998: Few facilities have issued actual data. Based on what data is available and projections of 1995 data, estimated total emissions are at least 1500 kilograms but likely, in light of the 1999 data, much higher [45].

- 1999: Emissions were originally estimated at 2100 kg but then "upgraded" to 2500 kg[46]. This sector now has the dubious distinction of ranking very closely next to the highest industrial sector source of mercury emissions in Canada [47]. Senes Consulting reported emissions in the order of 2200 kg [48].

- 2000: NPRI data for year 2000 was released for the first time for this sector in November 2001. Total air emissions reported are in the order of 2000 kg.

The trend to increasing mercury emissions from this sector is particularly problematic in that the reliance on coal-fired plants for generating electricity has increased in the last few years with no improvement in controls and no strategy or target in Canada in sight to drive mercury emissions downward. What is even more troubling, that with all the silence from industry about giving data, new coal plants are being proposed **despite assurances from this same industry in 1999 at CWS mercury meetings that no new plants were on the horizon.**

For a persistent, bioaccumulative toxin such as mercury, it is important to track mercury in its entirety – a life-cycle analysis in the operation of a coal plant. The amount of mercury in coal prior to combustion should be equivalent to the amount of mercury emitted from the stack (in the fly ash) to the atmosphere plus the amount of mercury captured by pollution control devices and its subsequent fate – be it landfill disposal, or, in by-products. **There can be no "missing mercury".**

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[43] The Ontario Hydro Method is now an accepted standard test method in Canada and the US for the determination of mercury emissions from coal-fired plants under some limitations.
[44] The Senes Report, March 1999
[45] Estimates prior to 1999 are currently under revision. It now appears that emissions for these years may be in the order of 1800 to 2000 kg.
[46] These figures were given at a CWS Mercury meeting in January 2001. The 2500 kg is suspected of being more realistic (Ian Smith, Champion, CWS Mercury)
[47] Author's own determinations
[48] Senes Consulting Final Draft Report - prepared for CCME, October 2001

In the interests of publishing relevant mercury data, I have endeavored to review and compile information from the limited number of sources available as well as deriving data by my own projections. Consequently, the data presented in this section may not necessarily be firm or complete. Rather, it is meant to give an indication of what is known and available in the public domain and what is not and should be. Quite possibly, and to no surprise, mercury emissions from years prior to 1999 may be far greater than what has been reported or presented in this document. In examining the data on emissions and other parameters, it seems plausible to assume a likely variation as high as 20%.

I have challenged industry on numerous occasions over the past 3 years to correct, amend and offer new and improved data – but the results of such pleas have been disappointing. On September 10, 2001, at a Mercury CWS – EPG Workshop held in Fredericton, NB, I issued an assignment to industry (and government) to verify existing data and supply missing data in the chart "Mercury Emissions Profile" that I had prepared for the meeting (Appendix E.3– Fredericton Presentation). The information was requested by the end of the year.

The results of this "Canadian Information Collection Request" by a Non-Government Representative were not exactly gratifying. Only New Brunswick and Nova Scotia Power replied with some information that was at least helpful. Ontario (OPG) indicated acceptance of my estimates verbally. Consequently, I am prepared to publish my own findings as representing the best that I can derive and what seems plausible. More to the point, I cannot expect voluntary efforts to produce any better results and fully support legislation for this sector with respect to providing essential information with regard to mercury emissions and other pollutants of concern.

4.3 Industry Perspective – Barriers Identified to Setting a Mercury Standard

- The inherent variation in mercury concentrations in coal from one sample to another
- Testing is expensive and not practical for all facilities.
- Contractual obligations with suppliers inhibit disclosure of mercury concentration
- Many variables and differences among facilities - type of coal, operating conditions and air pollution control devices
- The extent of inherent capture of mercury is complex (depends on speciation, composition of flue gas, temperature, type of ash).
- To date, no mercury technology is universally applicable.
- Comparisons of data between Canadian and US coal-fired plants may not be possible.
- We must wait for the US power industry to report.
- The US EPA Reference Dose (interim) of 0.1µg/kgbw/day is set to protect the most sensitive populations is based on acute (high) exposure in mercury poisoning in Iraq and is too restrictive. "If the Reference Dose were changed to 0.3 µg/kgbw/day (current dose Agency of Toxic Substances and Disease Registry, US), then 90% of US state fish advisories would not be required. This would dramatically change the level of control required on mercury emissions from coal-fired plants.

Recent Events in Response to Industry Concerns

Testing for Mercury Emissions: Mercury Stack Test Protocol: The "Ontario Hydro (OH) Method" is the preliminary standard reference for stack test protocol for speciated mercury emissions. Reliability of data is considered superior to data by other methods. The OH method has been mandated in the US EPA action to gather information on mercury emissions. Most Canadian Utilities have **voluntarily** committed to use this method. The data ***may*** determine feasibility of mercury emission controls and possible reductions.

Reference Dose: In July 2000, the National Academy of Sciences (NAS) NAS completed a review of the latest scientific evidence regarding the health effects of methylmercury. The Academy affirmed EPA's assessment of methylmercury toxicity and the level of its reference dose (RfD) of 0.1 ✚g/kg/day.

The US EPA Information Collection Request: The 1998 US EPA Utility Air Toxics Final Report to Congress cited uncertainties that needed to be addressed with respect to emissions of air toxics, in particular mercury, from oil- and coal-fired plants. The US EPA authorized an Information Collection Request (ICR) to obtain additional information on mercury emissions from these utilities. During the year 1999, the ICR effort was to gather relevant information on mercury and coal-fired facilities and improve the overall estimate of the amount of mercury emitted from these facilities individually and collectively on an annual basis**;** the speciation of the mercury emitted; and the effectiveness of the various control technologies in reducing the amount of each form of mercury emitted.

This information along with other studies on health and control option analyses, would serve to assist the EPA Administrator in determining whether regulation of emissions of air toxics by the electricity steam generating units was warranted. In the event that regulation would be deemed appropriate, the information being collected might also be used in developing an applicable emission standard and would be made available to the public (Refer to Chapter 6 in this document for more information on the US Regulatory Action and the ICR).

US Regulatory Action: In December 2000, the US EPA announced its decision to regulate emissions of mercury and other air toxics from coal and oil-fired power plants. The EPA will propose regulations by December 15, 2003 and issue final regulation by December 15, 2004. Compliance is expected by 2007.

At this stage, the barriers identified by the Canadian Industry are no longer defensible.

4.4 Mercury Data – Tables, Charts and Graphs

The information presented in this section in the various tables and charts provides a synopsis of the mercury air emissions inventory pertaining to coal-fired plants in Canada and the relative contribution of this sector to mercury emissions overall. In addition, analyses and projections of data are provided to serve as background in an appropriate determination of a Canada-wide standard for mercury emissions from coal-fired plants[49].

Figures 1- 6 provide a survey and analysis of air emissions of mercury, capacity and generation with respect to coal-fired plants. They portray the electric power generating sector's contribution to mercury air emissions relative to other major sector in Canada and summarize the existing data that is publicly available. On several occasions projections and estimates of data were done where none was available. The index of figures that includes tables, charts and graphs is as follows:

Figure 1 - Sectorial Contribution of Mercury Emissions to Air - shows the relative percent contribution of 6 major sectors to atmospheric mercury emissions in Canada for 1995 and 1999.

Figure 2 - Mercury Emissions from Coal-Fired Plants in Canada (1990-1999) – is an inventory of air emissions from coal-fired plants in Canada for the years 1990, 1995, 1998 and 1999.

Figure 3 - Provincial Contribution of Mercury-EPG Emissions (1999) – demonstrates the percent contribution of each plant with such facilities (1999 data).

Figure 4 - Mercury Air Emissions Profile (1999) – provides a detailed summary of 1999 data that includes for each facility (and boiler unit) the date commissioned, total capacity, generation and capacity factor; mercury emissions and emission rates and mercury content in coal. This table provides essential information used in subsequent tables and graphs. A separate table "Coal-Fired Plants - Capacity Estimates (1999)" (in EXCEL) showing capacity estimates is appended at the end of this chapter.

Figure 5 - National Pollutant Release Inventory (NPRI) Data - shows mercury releases to air, water and land and transfers as reported by facilities to the NPRI for the year 2000.

Figure 6 - Comparison of Mercury Emissions Data – 1999, 2000 – gives a comparison of mercury emissions to air data from three sources: Mercury Air Emissions Profile 1999, Senes Report data for 1999 and the NPRI as above.

The next set of figures provides an analysis of emission rates and projections in order to assist in the determination of an appropriate mercury emission standard to achieve significant reductions of mercury.

[49] The information is based on a careful analysis of what has been available and accessible as a public interest stakeholder in this process. The margin of error can be expected to range in the order of 10 to 20% in some cases.

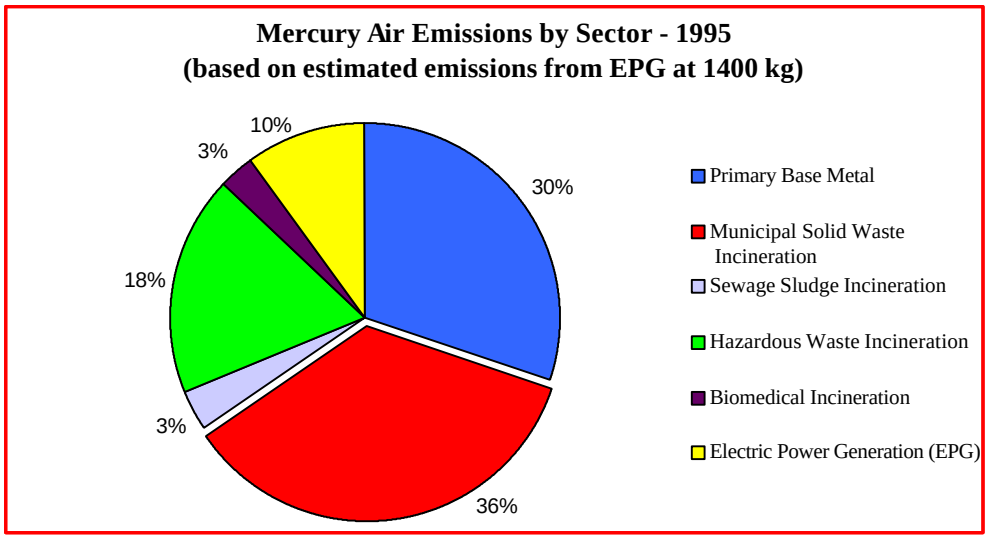
Figure 7 - Mercury Emission Rates and Ranking of Facilities (1999) – gives rating of facilities from highest to lowest in emission rates and includes coal type and speciation proportion. The intent of this chart is to explore features of facilities in terms of coal type and speciation that may affect the mercury emission rates.

Figure 8 – Top 7 emitters - highlights the largest 7 facilities in capacity, mercury emitted and mercury emission rates to give a sense as to which facilities merit priority attention.

Figure 9 – Graphs (2) of Mercury Emission Rate Projections uses data from "Mercury Emission Rate Projections – Scenarios" (EXCEL file appended at the end of this chapter) to plot mercury emissions as a function of rate to determine the appropriate range of rates to aim for in order to reduce mercury emissions. It also explores the effect that increased generation would have on emission rates.

Figure 1 **Mercury Emissions to Air – 6 Sectors**

	Mercury Emissions (Kilograms)					
SECTOR	**1995**	**1998**	**1999**	**1995 %**	**1998 %**	**1999 %**
Primary Base Metal	4300	2580	2580	30.6	46.0	39.0
Municipal Solid Waste Incineration	4880	446	446	34.9	7.9	6.7
Sewage Sludge Incineration	490	285	285	3.5	5.1	4.3
Hazardous Waste Incineration	2580	550	550	18.5	9.8	8.3
Biomedical Incineration	420	250	250	3.0	4.5	3.8
Electric Power Generation (EPG)	**1400**	1500	**2577**	10.0	26.7	39.0
Total	14070	5611	6688	100.5	100.0	101.2



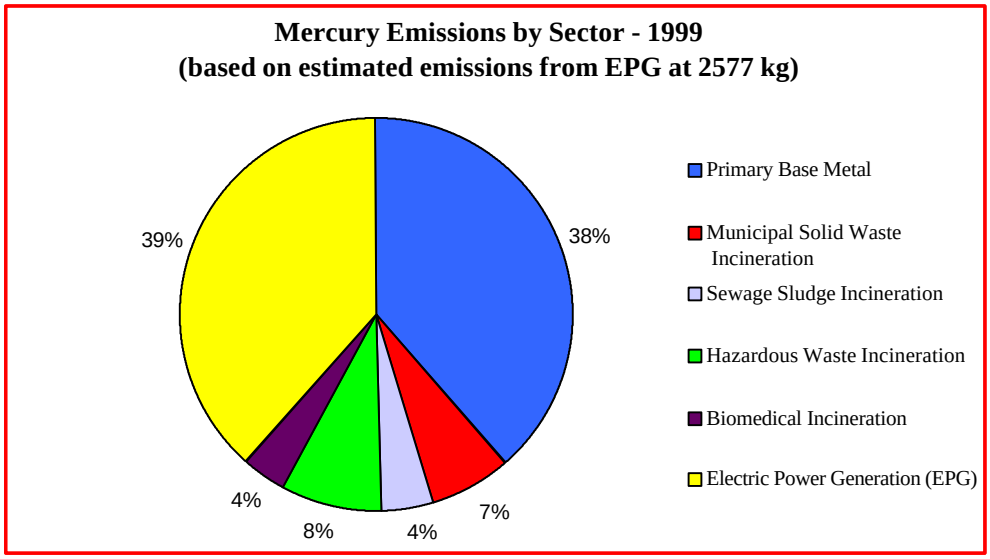


Figure 2 **Mercury Emissions from Coal-Fired Plants in Canada (1990-99)**

Province (Utility)	Facility	Atmospheric Emissions of Mercury (kg)				
		1990 [1]	1995 [2]	1995 [3]	1998/99 [4]	1999 [5]
Nova Scotia						
NS Power	Glace Bay	8	0			
	Lingan	**85**	**82**			**173**
	Macaan	2	0			
	Point Aconi	**0**	**14**			**3**
	Point Tupper	**22**	**17**			**37**
	Trenton	**43**	**41**			**54**
	Hydro/Import	9	9			
	Tufts Cove	2	1			
NS Total		**171**	**165**	**165**	**165**	**267**
New Brunswick						
NB Power	**Belledune**	**0**	**63**			**40**
	Chatham	1	0			
	Dalhousie	138	0			
	Grand Lake	**53**	**57**			**103**
	Courtney Bay	1	1			
	Dalhousie		10			
	Coleson Cove		5			
NB Total		**194**	**135**	**135**	**135**	**143**
Ontario						
OPG	**Atikokan**	**71**	**45**	**61**	**60**	**68**
	Lakeview	**26**	**10**	**17**	**70**	**87**
	Lambton	**182**	**163**	**265**	**120**	**135**
	Nanticoke	**66**	**152**	**62**	**260**	**260**
	Thunder Bay	**57**	**51**	**75**	**80**	**80**
	Lennox	1	0	0	0	0
Ontario Total		**403**	**421**	**481**	**590**	**630**

Figure 2 **Mercury Emissions from Coal-Fired Plants in Canada (1990-99)**

Province (Utility)	Facility	Atmospheric Emissions of Mercury (kg)				
		1990 [1]	1995 [2]	1995 [3]	1998/99 [4]	1999 [5]
Manitoba						
MB Hydro	**Brandon**	**24**	**7**		**6**	**6**
	Selkirk	**2**	**4**		**5**	**5**
Total		**26**	**10**	**10**	**11**	**11**
Saskatchewan						
SK Power	**Boundary Dam**	**101**	**126**			**275**
	Estevan	6	0			
	Poplar River	**115**	**113**			**290**
	Queen Elizabeth	0	2			
	Shand	**0**	**53**			**100**
Total		**222**	**293**	**293**	**293**	**665**
Alberta						
ATCO	**Battle River**	**56**	**49**			**172**
	HR Milner	**9**	**10**			**5**
	Sheerness	**44**	**81**			**123**
Epcor	**Genesee**	**14**	**24**			**106**
Trans Alta	**Keephills**	**31**	**32**			**98**
	Sundance	**77**	**90**	**80**		**278**
	Wabamun	**10**	**10**			**79**
Total		**240**	**296**	**286**	**286**	**861**
Grand Total		**1255**	**1320**	**1370**	**1480**	**2577**

Notes:

[1] 1990 - data based on Environment Canada Pollution Data Branch

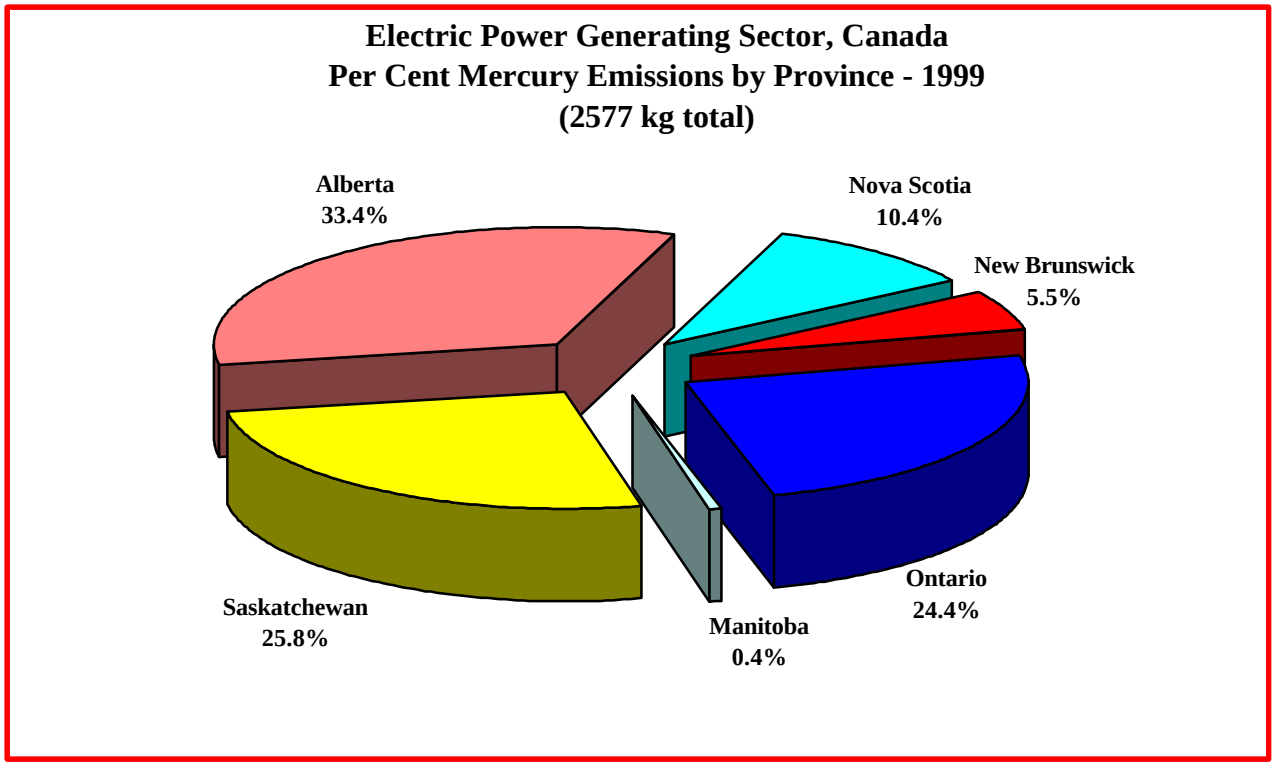
[2] 1995 data on the Senes Report, March 1999

[3] 1998 data on industry information to CWS- Mercury, March 2000

[4] Total for 1998 used 1995 where no 1998 data were available
(plus 10% for likely increase in generation)

[5] 1999 data from Mercury Air Emissions Profile 1999, Anna Tilman

Figure 3



This chart indicates the level of contribution of mercury emissions to air by each jurisdiction in Canada with such facilities. Alberta stands out as the largest contributor.

Figure 4 **Coal-Fired Plants in Canada – Mercury Emissions Profile 1999**

Province (Utility)	Facility (Boiler Units)	In-Service Dates	Capacity		Delivered (Net) Generation	Capacity Factor [7]	Mercury Emissions[1]	*Mercury* Coal Content[2]	Mercury Emission Rate
Units		**Year(s)**	**MW**	**GWh/year**	**GWh/year**	**%**	**kg**	**kg**	**mg/MWh (net gen.)**
Nova Scotia									
NSPI	**Lingan (4)**	79,80,83,84	600	5256	4500	86	**173**		38
	Point Aconi (1)	1994	165	1445	1060	73	**3**		3
	Point Tupper(1)	1973	150	1314	1155	88	**37**		32
	Trenton (2)	1969,91	310	2716	2250	83	**54**		24
NS Total [3]			**1225**	**10731**	**8965**		**267**	**220**	
New Brunswick									
NB Power	**Belledune (1)**	1993	480	4205	3780	90	**40**		11
	Grand Lake (1)	1964	61	534	347	65	**103**		297
NB Total [4]			**541**	**4739**	**4127**		**143**	**160**	
Ontario									
OPG [5]	**Atikokan (1)**	1985	215	1883	1112	59	**68**	96	61
	Lakeview (4)	62,63,67,69	1140	9986	3169	32	**87**	100	27
	Lambton (4)	69,70	1975	17301	8937	52	**135**	220	15
	Nanticoke (8)	73,74,75,76,78	3920	34339	18925	55	**260**	440	14
	Thunder Bay (2)	1981,82	310	2716	1611	59	**80**	120	50
Ontario Total			**7560**	**66226**	**33754**		**630**	**880**	
Manitoba									
MB Hydro	**Brandon (1)**		95	832	326	39	**6**	9	18
	Selkirk (2)		132	1156	199	17	**5**	6	25
Manitoba Total			**227**	**1988**	**525**		**11**	**15**	

Figure 4 **Coal-Fired Plants in Canada – Mercury Emissions Profile 1999**

Province (Utility)	Facility(Boiler Units)	In-Service Dates	Capacity		Delivered (Net) Generation	Capacity Factor [6]	Mercury Emissions[1]	Mercury Coal Content[2]	Mercury Emission Rate
Units		**Year(s)**	**MW**	**GWh/year**	**GWh/year**	**%**	**kg**	**kg**	**mg/MWh (net gen.)**
Saskatchewan									
SK Power	**Boundary Dam (6)**	59,60,69,70,73,78	875	7665	5820	76	**275**	320	47
	Poplar River (2)	1981,83	612	5361	4399	82	**290**	340	66
	Shand (1)	1992	300	2628	2325	88	**100**	125	43
Sask. Total [6]			**1787**	**15654**	**12544**		**665**	**785**	
Alberta									
ATCO	**Battle River (5)**	56,64,69,75,81	760	6658	4778	72	**172**		36
	HR Milner (1)	1973	150	1314	970	74	**5**		5
	Sheerness (2)	1986,90	760	6658	6062	91	**123**		20
Epcor	**Genesee (2)**	1989,94	820	7183	6588	92	**106**	120	16
TransAlta	**Keephills (2)**	1982,83	754	6605	5727	87	**98**	160	17
	Sundance (6)	70,73,76(2),77,80	1987	17406	15192	87	**278**		18
	Wabamun (4)	56,58,62,67	569	4984	3190	64	**79**	91	25
Alberta Total			**5800**	**50808**	**42507**		**861**	**1540**	
Grand Total			**17140**	**150146**	**102422**		**2577**	**3600**	

Notes:
1 1999 data from Senes Report March 2001, tables on cost estimates, CWS - Mercury
2 1999 data on industry information to CWS, March 2000 workshop (coal concentration, ppm fo a limited number of facilities)
3 Generation and mercury emissions were revised from earlier draft based on 1990/95 data to reflect 1999/2000 data from the Senes Report October 2001, and NSPI. Note that the amount of mercury emitted exceeds the mercury coal content - an issue yet to be resolved.
4 Information on capacity, generation and mercury emissions for 1999 were supplied by NB Government, September 2001
5 Coal-Fired Electricity Generation in Ontario, MOE, March 2001,
6 Saskatchewan emission data assume mercury capture to be about 15%. Data for mercury emissions submitted recently to NPRI and Senes are substantially lower and open to question.
7 Capacity Factor - Generation/Capacity in Percent

Figure 5

National Pollutant Release Inventory (NPRI) Data
Mercury Emissions From Coal-Fired Plants: Year 2000

NPRI Data Year 2000		On-Site Releases (in kilograms)				Transfers (in kilograms)	
Province (Utility)	**Facility (Boiler Units)**	**Air**	**Land**	**Water**	**Total**	**Disposal**	**Recycling**
Nova Scotia							
NSPI	**Lingan (4)**	173	3.3	0	176		
	Point Aconi (1)	3	21.7	0	25		
	Point Tupper(1)	37			37	1.9	
	Trenton (2)	54			54	9.8	6.2
NS Total		**267**	**25**		**292**	**12**	**6**
New Brunswick							
NB Power	**Belledune (1)**	43	66		110	8.2	108.3
	Grand Lake (1)	105			107		
NB Total		**148**	**66**		**217**	**8**	**108**
Ontario							
OPG	**Atikokan (1)**	35	1		36	0	1
	Lakeview (4)	27			27	0	20
	Lambton (4)	174	86		260	0	13
	Nanticoke (8)	229	198	1	428	0	80
	Thunder Bay (2)	56	1		57	0	1
Ontario Total		**521**	**286**		**808**	0	**115**
Manitoba							
MB Hydro	**Brandon (1)**	11	2.5		13.8	0	5.05
	Selkirk (2)	12	2.1		13.8	0	0
Manitoba Total		**23**	**4.6**		**28**	**0**	**5**
Saskatchewan							
SK Power	**Boundary Dam (6)**	105			105	0	0
	Poplar River (2)	115			115	0	0
	Shand (1)	54			54	0	0
Sask. Total		**274**			**274**		
Alberta							
ATCO	**Battle River (5)**	102			102	21.3	1.7
	HR Milner (1)	6			6	260	0
	Sheerness (2)	76	16.5		92		2.5
Epcor	**Genesee (2)**	104			104	83	0
TransAlta	**Keephills (2)**	102	159		260	0	0
	Sundance (6)	283	110		393	0	26.4
	Wabamun (4)	54	16.3		70.3	0	12.7
Alberta Total		**727**	**302**		**1027**	**364**	**43**
Grand Total		**1959**			**2646**	384	277

Figure 6 **Comparison of Mercury Emissions Data From Coal-Fired Plants in Canada**

Data Sources	Mercury – Air Emissions Profile (AT) 1999				Senes Report	NPRI
Province/Facility (Boiler Units)	1999 Mercury Emissions[1]	Delivered (Net) Generation	Revised Emissions 1999 [2]	Revised Generation (Net) [2]	1999 Mercury Air Emissions[3]	2000 Mercury Air Emissions[4]
	kg	GWh/year	kg	GWh/year	kg	kg
Nova Scotia						
Lingan (4)	**85**	4200	**173**	4500	193	173
Point Aconi (1)	**21**	1080	**3**	1060	6	3
Point Tupper(1)	**22**	970	**37**	1155	37	37
Trenton (2)	**43**	2000	**54**	2250	53	54
NS Total	**171**	**8250**	**267**	**8965**	**289**	**267**
New Brunswick						
Belledune (1)	**40**	3780			43	43
Grand Lake (1)	**103**	347			97	105
NB Total	**143**	**4127**	**143**		**140**	**148**
Ontario						
Atikokan (1)	**68**	1112			68	35
Lakeview (4)	**87**	3169			87	27
Lambton (4)	**135**	8937			134	174
Nanticoke (8)	**260**	18925			260	230
Thunder Bay (2)	**80**	1611			80	56
Ontario Total	**630**	**33754**	**630**		**629**	**522**
Manitoba						
Brandon (1)	**6**	326			6	11
Selkirk (2)	**5**	199			5	12
Manitoba Total	**11**	**525**	**11**		**11**	**23**
Saskatchewan						
Boundary Dam (6)	**284**	5820	**275**	5820	110	105
Poplar River (2)	**300**	4399	**290**	4399	111	115
Shand (1)	**100**	2325	**100**	2325	56	54
Sask. Total	**684**	**12544**	**665**		**277**	**274**
Alberta						
Battle River (5)	**172**	4778			192	102
HR Milner (1)	**5**	970			5	6
Sheerness (2)	**123**	6062			123	76
Genesee (2)	**106**	6588			106	104
Keephills (2)	**98**	5727			97	102
Sundance (6)	**278**	15192			278	283
Wabamun (4)	**79**	3190			79	54
Alberta Total	**861**	**42507**	**861**		**880**	**727**
Grand Total	**2500**	**101707**	**2577**	102422	**2226**	**1960**

Notes:
1 1999 data from Mercury Air Emissions Profile 1999, A. Tilman
2 1999 data amended based on review of information from industry, Senes Report and/or government sources
3 1999 Data, Table 2.3 "1999 Canadian Emissions from Coal-Fired Power Plants", Senes Report Final Draft Oct. 2001
4 NPRI Data for Year 2000 - Available (public) November 28, 2001

Figure 7 **Mercury Emission Rates and Facility Rankings (1999)**

Ranking in Rate	Facility/Province (Boiler Units)	Generation GWh	Mercury Emissions kg	Rate mg/MWh	Coal Type[1]	Mercury Elemental Form %[2]
1	**Grand Lake, NB (1)**	347	103	**297**	Bituminous	40
2	**Poplar River, SK (2)**	4399	290	**66**	Lignite	83
3	**Atikokan, ON (1)**	1112	68	**61**	Lignite	93
4	**Thunder Bay, ON (2)**	1611	80	**50**	Lignite/PRB	96
5	**Boundary Dam, SK (6)**	5820	275	**47**	Lignite	85
6	**Shand, SK (1)**	2325	100	**43**	Lignite	85
7	**Lingan, NS (4)**	4500	173	**38**	Bituminous	95
8	**Battle River, AB (3)**	4778	172	**36**	Sub-bit	86
9	**Point Tupper, NS (1)**	1155	37	**32**	Bituminous	47
10	**Lakeview , ON(4)**	3169	87	**27**	Bituminous	33
11	**Selkirk, MB (2)**	199	5	**25**	Sub-bit	80
12	**Wabamun, AB (4)**	3190	79	**25**	Sub-bit	79
13	**Trenton, NS (2)**	2250	54	**24**	Bituminous	95
14	**Sheerness, AB (2)**	6062	123	**20**	Sub-bit	81
15	**Brandon, MB (1)**	326	6	**18**	Sub-bit	79
16	**Sundance, AB (6)**	15192	278	**18**	Sub-bit	85
17	**Keephills, AB (2)**	5727	98	**17**	Sub-bit	71
18	**Genesee, AB (2)**	6588	106	**16**	Sub-bit	79
19	**Lambton, ON (4)**	8937	135	**15**	Bit/Petcoke	47
20	**Nanticoke, ON (8)**	18925	260	**14**	Bit/PRB	53
21	**Belledune, NB (1)**	3780	40	**11**	Bituminous	75
22	**HR Milner, AB (1)**	970	5	**5**	Bituminous	95
23	**Point Aconi, NS (1)**	1060	3	**3**	Bituminous	19
	Total	**102422**	**2577**			

Facilities are ranked in order of mercury emission rates. The median value is 25 mg/MWH - (Wabamun). A number of facilities with higher rates use lignite coal and tend to emit a higher percentage of the elemental form of mercury. The situation at Grand Lake, NB appears unique in that respect and its high mercury emission rate would be more dependent on lack of control equipment than on the type of coal burned.

Notes:.

[1] PRB: Powder River Basin Coal. Sub-bit: Sub-bituminous

[2] Mercury is emitted in three forms (species): Elemental, Ionic and Particulate.

On average, 70% of the emissions are in elemental form and 29% in ionic form, and particulate generally less than 1%. (Senes - Final Draft October 2001).

Figure 8

The Top Seven Coal Plant Mercury Emitters in Canada, 1999

LIST A			LIST B			LIST C		
Largest Facilities in MW Capacity	**Mercury kg**	**Emission Rate mg/MWh**	**Facilities with Greatest Mercury Emissions**	**Mercury kg**	**Emission Rate mg/MWh**	**Facilities with Greatest Emission Rate**	**Mercury kg**	**Emission Rate mg/MWh**
Nanticoke, ON	**260**	14	**Poplar River, SK**	**290**	66	**Grand Lake, NB**	103	**297**
Sundance, AB	**278**	18	**Boundary Dam, SK**	**275**	47	**Poplar River, SK**	290	**66**
Lambton, ON	**135**	15	**Sundance, AB**	**278**	18	**Atikoken, ON**	68	**61**
Lakeview, ON	**87**	27	**Nanticoke, ON**	**260**	14	**Thunder Bay, ON**	87	**50**
Boundary Dam, SK	**275**	47	**Lingan, NS**	**173**	38	**Boundary Dam, SK**	275	**47**
Genessee, AB	**106**	16	**Battle River, AB**	**172**	36	**Shand, SK**	100	**43**
Keephills, AB	**98**	17	**Lambton, ON**	**135**	15	**Lingan, NS**	173	**38**
Total Mercury	**1239**		**Total Mercury**	**1583**		**Total Mercury**	**1096**	

Colour Code:

Facilities in Lists A,B and C:	Boundary Dam
Facilities in Lists A and B:	Nanticoke, Sundance, Lambton
Facilities in Lists B and C	Poplar River, Lingan

Figure 9(a)

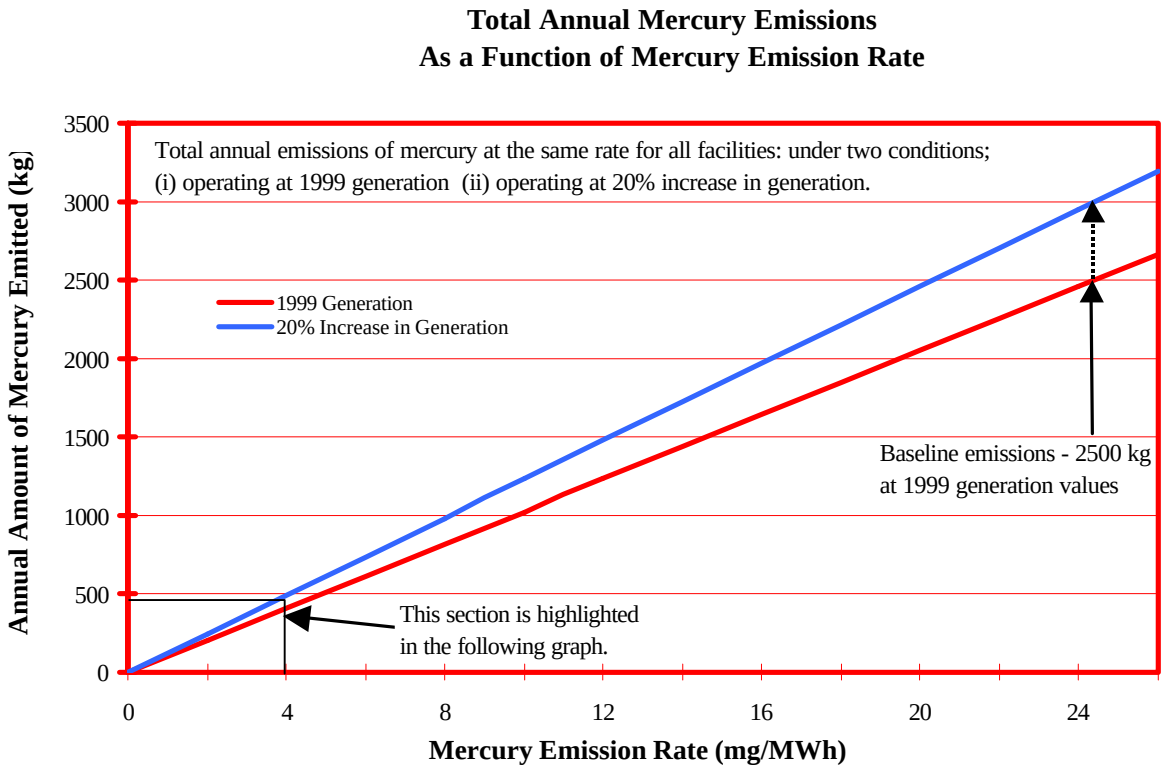
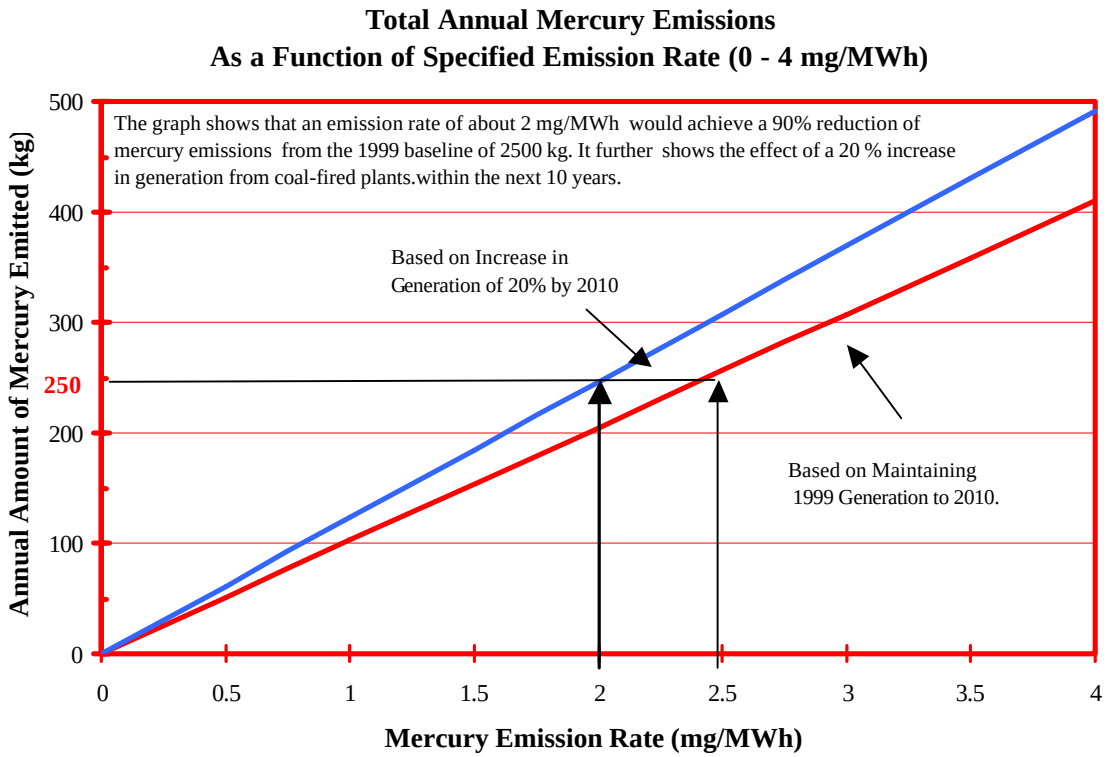


Figure 9(b)



4.5 Information Required – The Missing Pieces

Several factors have been identified in the CWS process as missing links that are essential not only for the purpose of improving accuracy, accessibility and details needed to determine a standard but also to assist in the development of a reporting and monitoring protocol. The lack of publicly accessibility to information from this sector has been a particularly thorny issue.

The U.S. has conducted an "Information Collection Request (ICR)" specifically for developing an applicable emission standard with respect to coal-fired plants and mercury emissions[50]. It is both appropriate and necessary for Canada to conduct a similar information request to obtain the required information and clarify the uncertainties shrouded by this industry.

Following is a description of what should be included in such a request.

Canadian Information Collection Effort (CICE)

All facilities would be required to submit the specific information requested within one year. Subsequent to this, the frequency of submission of relevant information e.g., annual, quarterly) would be determined according to specific purposes for which intended. Components of the information gathering exercise are:

1. **Operating conditions for each plant and boiler**

- Plant location, boiler units, year commissioned
- Fuel type and source
- Capacity, generation and safety margin
- Pollution controls - in general and mercury-specific (in place and planned)
- Plans for modifications (expansion, closures)

2. **Coal Analysis**

- Amount of coal fired (tonnes)
- Heating value (Btu/kWh)
- Total sulphur (%)
- Mercury (ppm)
- Chlorine (ppm)
- Mercury content (ppm)
- Ash (%)
- Coal sampling methodology, frequency, analysis, accuracy and precision

[50] Background and details of the ICR request are found in Chapter 7 of this document. The ICR data is publicly available information.

3. Mercury–Specific Information

- Atmospheric emissions of mercury and speciation data[51]
- Mass balance analysis of mercury
- Amount of mercury captured and its fate (landfill, etc.)

4.6 Summary

In order to set a CWS for mercury for coal-fired plants, a standard for new facilities that applies upon start-up should be established. This standard would then apply to existing facilities for compliance by a specified date, such as 2010. The potential for increases in generation and corresponding increases in mercury emissions must be factored into setting the standard as well as a cautious consideration of a safety margin. Based on the data presented in this section (in particular, Figures 9), a uniform national emission standard that would result in a 90% reduction in mercury emissions from 1999 levels should be at maximum 1.8 mg/MWh (This value incorporates a 20% safety margin).

Despite the shortcomings of the information available, it is possible to derive a mercury emission rate standard now for coal-fired plants that would achieve significant reductions in mercury emissions. Having more and better information would assist in the review of the standard, and in monitoring the performance of the facilities over time.

4.7 Data References for this Chapter:

1) *Electric Power in Canada 1997 – Canadian Electrical Association, Natural Resources Canada*
2) *Senes Report (final Draft) – Evaluation of Technologies for Reducing Mercury Emissions, March 2001 and March 1999*
3) *Canadian Emissions Inventory of Mercury (1990 data) Pollution Control Branch, Environment Canada*
4) *Accelerated Reduction/Elimination of Toxics (ARET) Program, 1998.*
5) *Toward Sustainable Development, Ontario Hydro 1997 Progress Report*
6) *Toronto Public Health "Ontario's Changing Electrical Sector: Implications for Air Quality and Human Health, March 1999*
7) *Strategic Options for Management of Toxics Substances (SOP)– Electric Power Generation (Fossil Fuel) Sector, Environment Canada and Health Canada, April 1997*
8) *Controlling of Mercury from Electricity Generating Boilers, Northeast States for Coordinated Management (NESCAUM), March 1999*
9) *Analysis of Emissions Reduction Options for the Electric Power Industry, US EPA, March 1999*
10) *Ontario Hydro Method Information*
11) *Mercury White Paper – US EPA, December 2000*
12) *Fact Sheet – Utility Air Toxics Determination, US EPA December 14, 2000*

[51] Tests use the Ontario Hydro (OH) Method (recommended three separate runs at each sample location measuring inlet and outlet concurrently with concurrent coal sampling during each test period)

13) *Information Request for Electric Utility Steam Generating Unit – Mercury Emissions Information Collection Effort, Emissions Standards Division, U.S. EPA, November 16, 1998*
14) *Utility Air Toxics Study Report to Congress, US EPA Executive Summary February 1998*
15) *Mercury Study Report to Congress – Overview US EPA 1998*
16) National Academy of Sciences – Toxicological Effects of Mercury, July 11, 2002

Coal - Fired Plants in Canada
Capacity Estimates - 1999

Province (Utility)	Facility (Boiler Units)	In-Service Dates (Commissioned)	Capacity in MegaWatts (MW) (Net/Gross/Installed)					
Data Reference Source			**Mercury Emissions Profile[1]**	**Plant Data Environment Canada**	**Facility Websites**	**CEA-1997 (Installed)[2]**	**CWS Data March 2000[3]**	**Nameplate or Net Capacity Senes[4]**
Nova Scotia								
NSPI	**Lingan (4)**	1979, 80, 83,84	600	633	600		620	620
	Point Aconi (1)	1994	165	165	185		165	165
	Point Tupper(1)	1973	150	150	150		148	148
	Trenton (2)	1969,91	310	343	310		305	305
NS Total [3]			**1225**	**1291**	**1245**	**1383**	**1238**	**1238**
New Brunswick								
NB Power	**Belledune (1)**	1993	480	450	458		480	480
	Grand Lake (1)	1964	61	60	57		61	61
NB Total [4]			**541**	**510**	**515**	**892**	**541**	**541**
Ontario								
OPG	**Atikokan (1)**	1985	215	230	215		215	215
	Lakeview (4)	1962,63,67,69	1140	1200	1140	1200	1200	1140
	Lambton (4)	1969,70	1975	2040	1975	2020	2040	1976
	Nanticoke (8)	1973,74,75,76,78	3920	4040	3920	3985	4040	3920
	Thunder Bay (2) [5]	1981,82	310	310	310		330	310
Ontario Total			**7560**	**7820**	**7560**	**7772**	**7825**	**7561**
Manitoba								
MB Hydro	**Brandon (1)**		95	105	97		105	105
	Selkirk (2)		132	132	139		132	132
Manitoba Total			**227**	**237**	**236**	**237**	237	237

Coal - Fired Plants in Canada
Capacity Estimates - 1999

Province (Utility)	Facility (Boiler Units)	In-Service Dates (Commissioned)	Capacity in MegaWatts (MW) (Net/Gross/Installed)					
Data Reference Source			**Mercury Emissions Profile[1]**	**Plant Data Environment Canada**	**Facility Websites**	**CEA-1997 (Installed)[2]**	**CWS Data March 2000[3]**	**Nameplate or Net Capacity Senes[4]**
Saskatchewan								
SK Power	**Boundary Dam (6)**	1959, 60,69,70,73,78	875	875	875	875	887	874
	Poplar River (2) [6]	1981,83	612	592	612		615	600
	Shand (1)	1992	300	300	300		305	300
Sask. Total			**1787**	**1767**	**1787**	**1766**	**1807**	**1774**
Alberta								
ATCO [7]	**Battle River (5)**	1956,64,69,75,81	760	740	**760**		760	675
	HR Milner (1)	1973	150	150	145		160	150
	Sheerness (2)	1986,90	760	766	760		796	796
Epcor	**Genessee (2)**	1989,94	820	812	820	820	762	820
	Keephills (2)	1982,83	754	806	754	800	762	806
TransAlta	**Sundance (6)**	1970,73,76,76,77,80	1987	2100	1987	2111	1981	1991
	Wabamun (4)	1956,58,62,67	569	582	569		545	548
Alberta Total			**5800**	**5956**	**5795**	**5962**	**5766**	**5786**
Grand Total			**17140**	**17581**	**17138**	**18012**		**17401**
						(-300) [6]		
						17712 (revised)		

Notes:
1 1999 data from Mercury Emissions Profile collected and estimated by Anna Tilman
2 Canadian Electricity Association (CEA) Electric Power in Canada 1997
3 Industry information presented at the CWS, March 2000 workshop
4 1999 Data from the Senes Report, October 2001.
Generation values for Ontario facilities and Point Aconi, NS are net.
5 Modification made in 1996, 10MW added to each unit
6 Note: Dalhousie NB (300MW) converted in 1994, accounting for CEA total greater by 300 MW.

Coal-Fired Plants in Canada
Mercury Emissions Rate Projections

				Projected Annual Mercury Emissions (in kilograms) for Specified Emissions Rates (in mg/MWh)					
Province/Facility (Boiler Units)	**Delivered Generation for 1999**	**Mercury Emissions 1999[1]**	**Mercury Emission Rate 1999**	**Mercury Emissions @ 15 mg/MWh**	**Mercury Emissions @ 12.5 mg/MWh**	**Mercury Emissions @ 10 mg/MWh**	**Mercury Emissions @ 5 mg/MWh**	**Mercury Emissions @ 2.5 mg/MWh**	**Mercury Emissions @ 2 mg/MWh**
Units	**GWh/year**	**kg**	**mg/MWh**	**kg**	**kg**	**kg**	**kg**	**kg**	**kg**
Nova Scotia									
Lingan (4)	4500	**173**	38	68	56	45	23	11	9
Point Aconi (1)	1060	**3**	3	16	13	11	5	3	2
Point Tupper(1)	1155	**37**	32	17	14	12	6	3	2
Trenton (2)	2250	**54**	24	34	28	23	11	6	5
NS Total [3]	**8965**	**267**		**134.5**	**112.1**	**89.7**	**44.8**	**22.4**	**17.9**
New Brunswick									
Belledune (1)	3780	**40**	11	57	47	38	19	9	8
Grand Lake (1)	347	**103**	297	5	4	3	2	1	1
NB Total [4]	**4127**	**143**		**62**	**52**	41	21	10	8
Ontario									
Atikokan (1)	1112	**68**	61	17	14	11	6	3	2
Lakeview (4)	3169	**87**	27	48	40	32	16	8	6
Lambton (4)	8937	**135**	15	134	112	89	45	22	18
Nanticoke (8)	18925	**260**	14	284	237	189	95	47	38
Thunder Bay (2)	1611	**80**	50	24	20	16	8	4	3
Ontario Total	**33754**	**630**		**506**	**422**	**338**	**169**	**84**	**68**
Manitoba									
Brandon (1)	326	**6**	18	5	4	3	2	1	1
Selkirk (2)	199	**5**	25	3	2	2	1	0	0
Manitoba Total	**525**	**11**		**8**	**7**	**5**	**3**	**1**	**1**

Coal-Fired Plants in Canada
Mercury Emissions Rate Projections

				Projected Annual Mercury Emissions (in kilograms) for Specified Emissions Rates (in mg/MWh)					
Province/Facility (Boiler Units)	**Delivered Generation for 1999**	**Mercury Emissions 1999[1]**	**Mercury Emission Rate 1999**	**Mercury Emissions @ 15 mg/MWh**	**Mercury Emissions @ 12.5 mg/MWh**	**Mercury Emissions @ 10 mg/MWh**	**Mercury Emissions @ 5 mg/MWh**	**Mercury Emissions @ 2.5 mg/MWh**	**Mercury Emissions @ 2 mg/MWh**
Units	**GWh/year**	**kg**	**mg/MWh**	**kg**	**kg**	**kg**	**kg**	**kg**	**kg**
Saskatchewan									
Boundary Dam (6)	5820	**275**	47	87	73	58	29	15	12
Poplar River (2)	4399	**290**	66	66	55	44	22	11	9
Shand (1)	2325	**100**	43	35	29	23	12	6	5
Sask. Total	**12544**	**665**		**188**	**157**	**125**	**63**	**31**	**25**
Alberta									
Battle River (3)	4778	**172**	36	72	60	48	24	12	10
HR Milner (1)	970	**5**	5	15	12	10	5	2	2
Sheerness (2)	6062	**123**	20	91	76	61	30	15	12
Genessee (2)	6588	**106**	16	99	82	66	33	16	13
Keephills (2)	5727	**98**	17	86	72	57	29	14	11
Sundance (6)	15192	**278**	18	228	190	152	76	38	30
Wabamun (4)	3190	**79**	25	48	40	32	16	8	6
Alberta Total	**42507**	**861**		**638**	**531**	425	213	106	85
Grand Total	**102422**	**2577**		**1536**	**1280**	**1024**	**512**	**256**	**205**
Allowance for 20% Increase in Total Generation	**122906**	**3092.4**		**1844**	**1536**	**1229**	**615**	**307**	**246**

Coal-Fired Plants in Canada
Mercury Emissions Rate Projections

				Projected Emissions Rates (in mg/MWh) based on Per Cent Mercury Reduction (50, 70, 90 Per Cent)					
Province/Facility (Boiler Units)	**Delivered Generation for 1999**	**Mercury Emissions 1999[1]**	**Mercury Emission Rate 1999**	**Mercury Emission 50% reduction**	**Equivalent Emission Rate - 50%**	**Mercury Emission 70% reduction**	**Equivalent Emission Rate - 70%**	**Mercury Emission 90% reduction**	**Equivalent Emission Rate - 90%**
Units	**GWh/year**	**kg**	**mg/MWh**	**kg**	**mg/MWh**	**kg**	**mg/MWh**	**kg**	**mg/MWh**
Nova Scotia									
Lingan (4)	4500	**173**	38	87	19	51.9	11.5	17.3	3.8
Point Aconi (1)	1060	**3**	3	2	1	0.9	0.8	0.3	0.3
Point Tupper(1)	1155	**37**	32	19	16	11.1	9.6	3.7	3.2
Trenton (2)	2250	**54**	24	27	12	16.2	7.2	5.4	2.4
NS Total [3]	**8965**	**267**		**134**		**80**		**27**	
New Brunswick									
Belledune (1)	3780	**40**	11	20	5	12	3.2	4.0	1.1
Grand Lake (1)	347	**103**	297	52	148	30.9	89.0	10.3	29.7
NB Total [4]	**4127**	**143**		**72**		**43**		**14**	
Ontario									
Atikokan (1)	1112	**68**	61	34	31	20.4	18.3	6.8	6.1
Lakeview (4)	3169	**87**	27	44	14	26.1	8.2	8.7	2.7
Lambton (4)	8937	**135**	15	68	8	40.5	4.5	13.5	1.5
Nanticoke (8)	18925	**260**	14	130	7	78	4.1	26.0	1.4
Thunder Bay (2)	1611	**80**	50	40	25	24	14.9	8.0	5.0
Ontario Total	**33754**	**630**		**315**		**189**		**63**	
Manitoba									
Brandon (1)	326	**6**	18	3	9	1.8	5.5	0.6	1.8
Selkirk (2)	199	**5**	25	3	13	1.5	7.5	0.5	2.5
Manitoba Total	**525**	**11**		**6**		**3.3**		**1.1**	

Coal-Fired Plants in Canada
Mercury Emissions Rate Projections

				Projected Emissions Rates (in mg/MWh) based on Per Cent Mercury Reduction (50, 70, 90 Per Cent)					
Province/Facility (Boiler Units)	**Delivered Generation for 1999**	**Mercury Emissions 1999[1]**	**Mercury Emission Rate 1999**	**Mercury Emission 50% reduction**	**Equivalent Emission Rate - 50%**	**Mercury Emission 70% reduction**	**Equivalent Emission Rate - 70%**	**Mercury Emission 90% reduction**	**Equivalent Emission Rate - 90%**
	GWh/year	**kg**	**mg/MWh**	**kg**	**mg/MWh**	**kg**	**mg/MWh**	**kg**	**mg/MWh**
Saskatchewan									
Boundary Dam (6)	5820	**275**	47	138	24	82.5	14.2	27.5	4.7
Poplar River (2)	4399	**290**	66	145	33	87	19.8	29.0	6.6
Shand (1)	2325	**100**	43	50	22	30	12.9	10.0	4.3
Sask. Total	**12544**	**665**		**333**		**199.5**		**66.5**	
Alberta									
Battle River (3)	4778	**172**	36	86	18	51.6	10.8	17.2	3.6
HR Milner (1)	970	**5**	5	3	3	1.5	1.5	0.5	0.5
Sheerness (2)	6062	**123**	20	62	10	36.9	6.1	12.3	2.0
Genessee (2)	6588	**106**	16	53	8	31.8	4.8	10.6	1.6
Keephills (2)	5727	**98**	17	49	9	29.4	5.1	9.8	1.7
Sundance (6)	15192	**278**	18	139	9	83.4	5.5	27.8	1.8
Wabamun (4)	3190	**79**	25	40	12	23.7	7.4	7.9	2.5
Alberta Total	**42507**	**861**		**431**					
Grand Total	**102422**	**2577**		**1289**		**258**		**86**	
Allowance for 20% Increase in Total Generation	**122906**	**3092.4**		**1546**		**310**		**103**	

5 Cumulative Emissions – The True Loading Picture

5.1 Introduction

In the year 1999 alone, the total amount of atmospheric mercury emissions from coal-fired plants in Canada was approximately 2500 kilograms. Relative to other major sectors of mercury emitters, coal-fired plants are presumably the largest contributor of mercury into the atmosphere in Canada, accounting for approximately 39 per cent of Canada's total such emissions[52]. Furthermore, this sector is gaining further notoriety as a "growing mercury contributor" in light of recent proposals and approvals for expanded coal-fired plants in Alberta[53].

Focusing strictly on yearly emissions masks a highly significant property of mercury – its persistency. A more realistic depiction of the loading of mercury into the environment would result if one were to account for the cumulative emissions of mercury from these facilities over a period of time, such as a 20 year span or even more realistic, the lifetime of their operation. For instance, if the accumulation of emissions is aggregated over a twenty-year period, the total amount of mercury emitted is in the order of 50-60 tonnes.

Considering that some of these facilities that are operating today have been on line for close to 50 years, their lifetime legacy of mercury emissions is very substantial. It is even more disturbing to consider the ramifications of growth in this sector without the appropriate standards in place to control and prevent these emissions.

The focus of this chapter is to provide a graphical impression of the cumulative emissions of mercury from several perspectives; portraying the overall picture in Canada from the total of all such facilities in Canada, facilities on an individual basis, regional clusters of plants and province-wide aggregation of total cumulative emissions over their lifetime. The various scenarios presented explore the impact of early reductions in emissions versus "business as usual" or in some instances, expansion of facilities.

Emphasis is placed on those provinces and facilities that contribute the most to atmospheric mercury emissions in Canada from this sector and are undergoing extensive activity. Consequently, facilities in Alberta (Section 5.3) and Ontario (Section 5.4) are covered much more extensively while similar but much more abbreviated analyses are done on Saskatchewan, New Brunswick and Nova Scotia (Sections 5.5, 5.6 and 5.7).

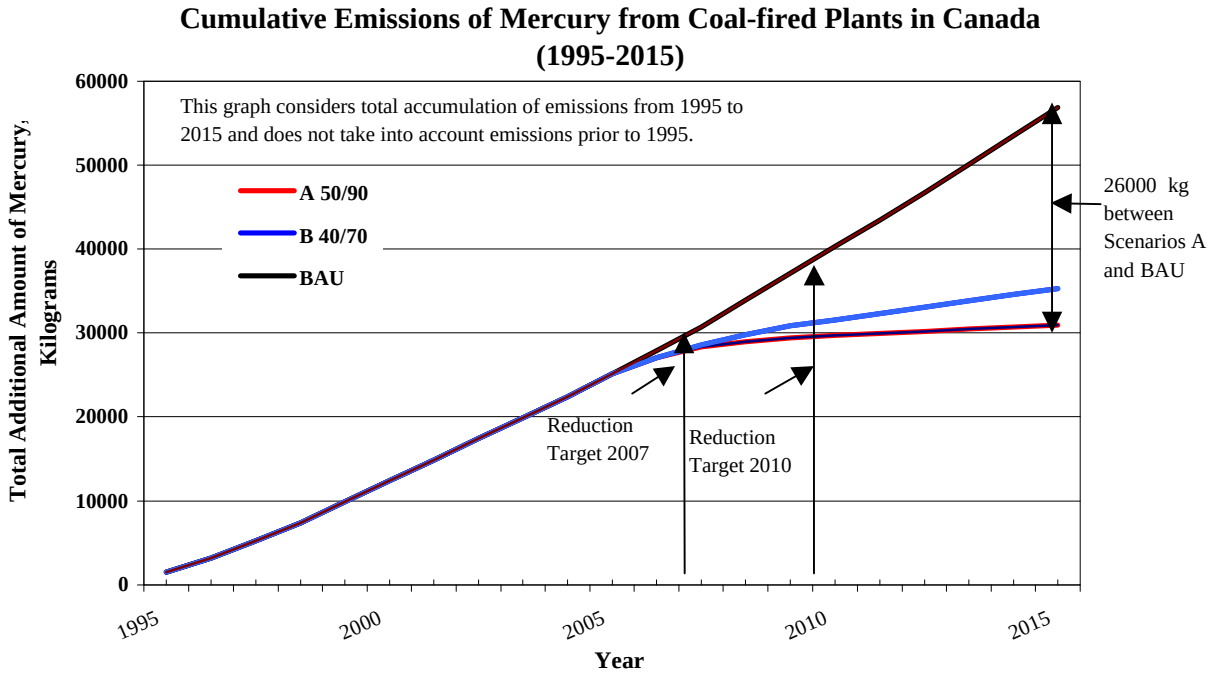
The examination of the cumulative aspect of mercury emissions from coal-fired plants is to underscore the importance of early action in setting stringent mercury emissions standards if the increase in cumulative emissions is to be abated in any significant manner.

[52] Refer to Sector Air Emissions – Figure 1, Chapter 4 in this document.
[53] New plant proposals to date for 2005 are: Keephills (TransAlta) – 900 MW, EPCOR – 450 MW and ENMAX and Fording – 400 MW, about 10% of the current coal-plant capacity in Canada.

5.2 The Canadian Scene – 20 Years Accumulation

The following graph gives an indication of the extent of the total accumulated amount of mercury emitted in Canada from coal-fired plants projected over a 20-year span from 1995-2015. The three scenarios presented are:
BAU - Business As Usual, that is, no reductions; "50/90" scenario, emission reductions of 50% by 2007 and 90% by 2010 (1999 base year); and "40/70" scenario, representing a 40% reduction by 2007 and 70% by 2010.

Figure 5.2



While all three curves show the **increase** in the accumulated amount of mercury in the environment, only when attempts are made to reduce annual emissions (as in scenarios A and B) in the year 2007 and 2010 does **the rate at which the total amount of mercury accumulates begin to lessen.** The crucial factors that affect this rate are the dates at which reductions of annual emissions commence and the actual amount of the annual reductions.

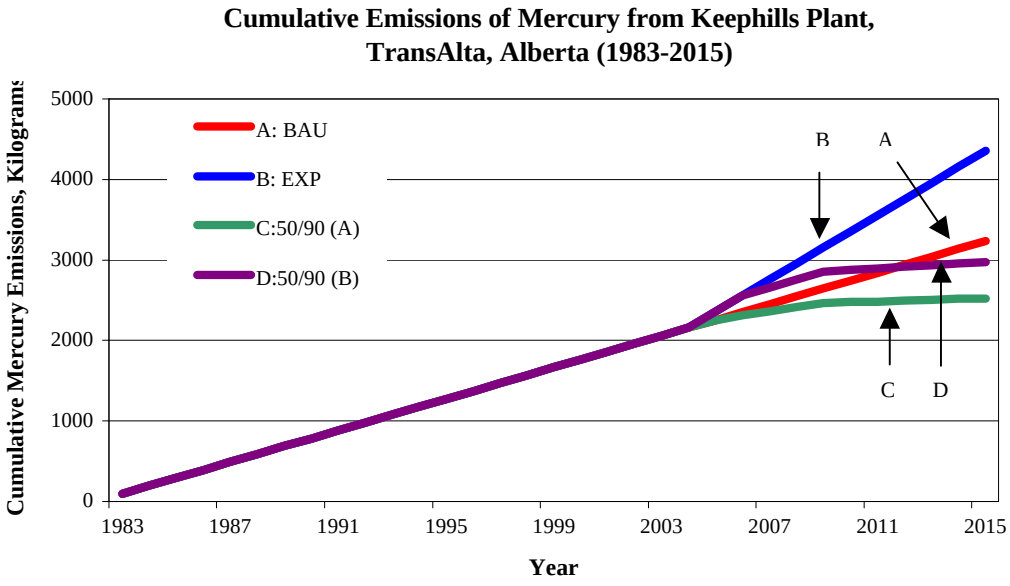
The graph makes it all the more evident that the longer it takes to implement a standard that would significantly reduce mercury emissions, the more problematic the mercury loading factor will be both locally and long-range.

5.3 Alberta: Cumulative Emissions

The cumulative mercury emissions from facilities in Alberta are projected over designated time spans and scenarios for specific plants as well as a cluster of four plants situated in the Lake Wabamun – Genesee Area, an area of extensive activity. The plants studied in these cases are Lake Wabamun, Sundance and Keephills (TransAlta) and Genesee (EPCOR). Both TransAlta and EPCOR have received approval from the Alberta Utilities Board for expansions of their facilities at Keephills and Genesee respectively for start-up in 2005.

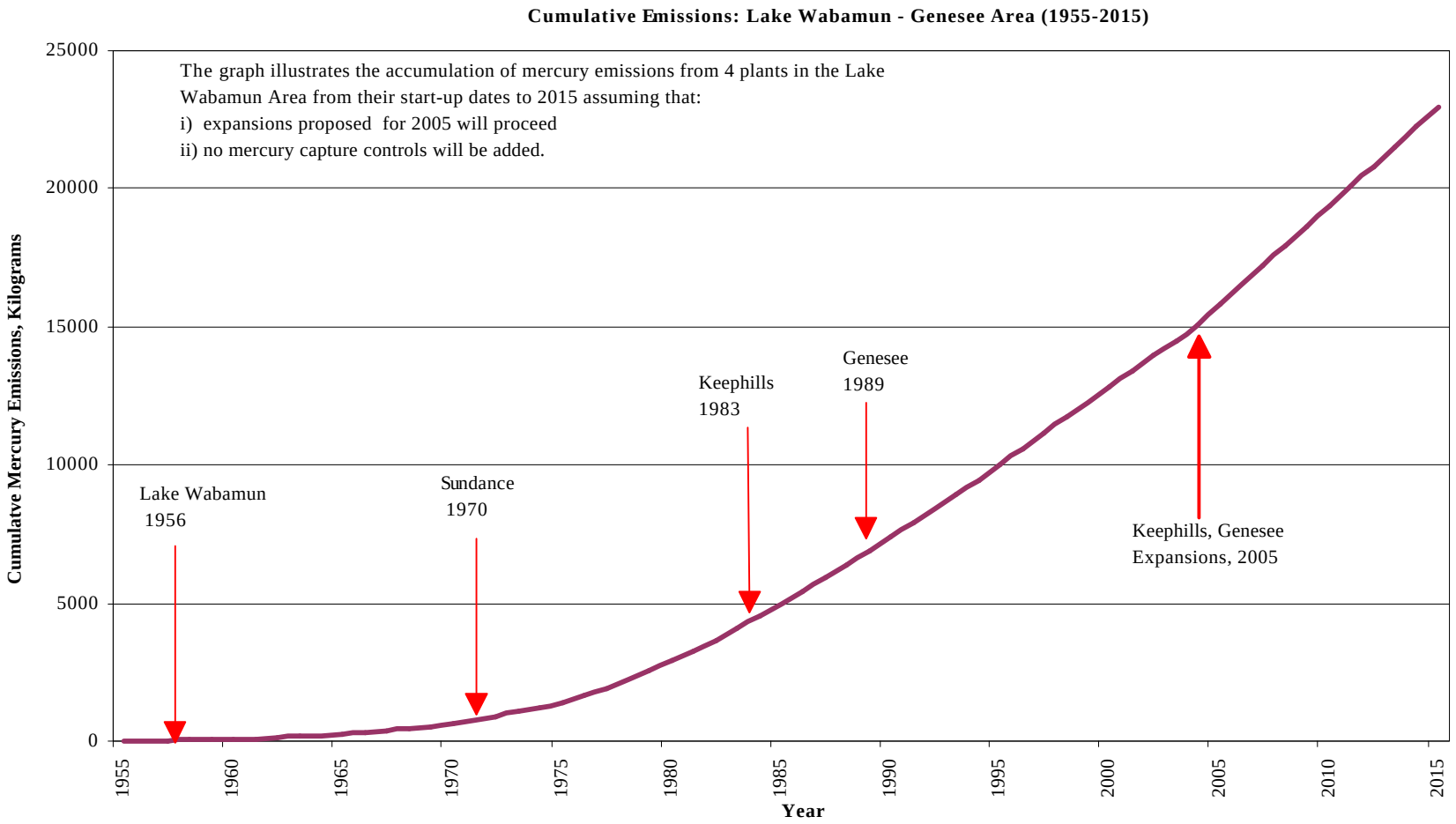
The following graph displays the Keephills facility from its initial year commissioned (1983) projected to the year 2015 under 4 scenarios as explained below.

Figure 5.3 (i)



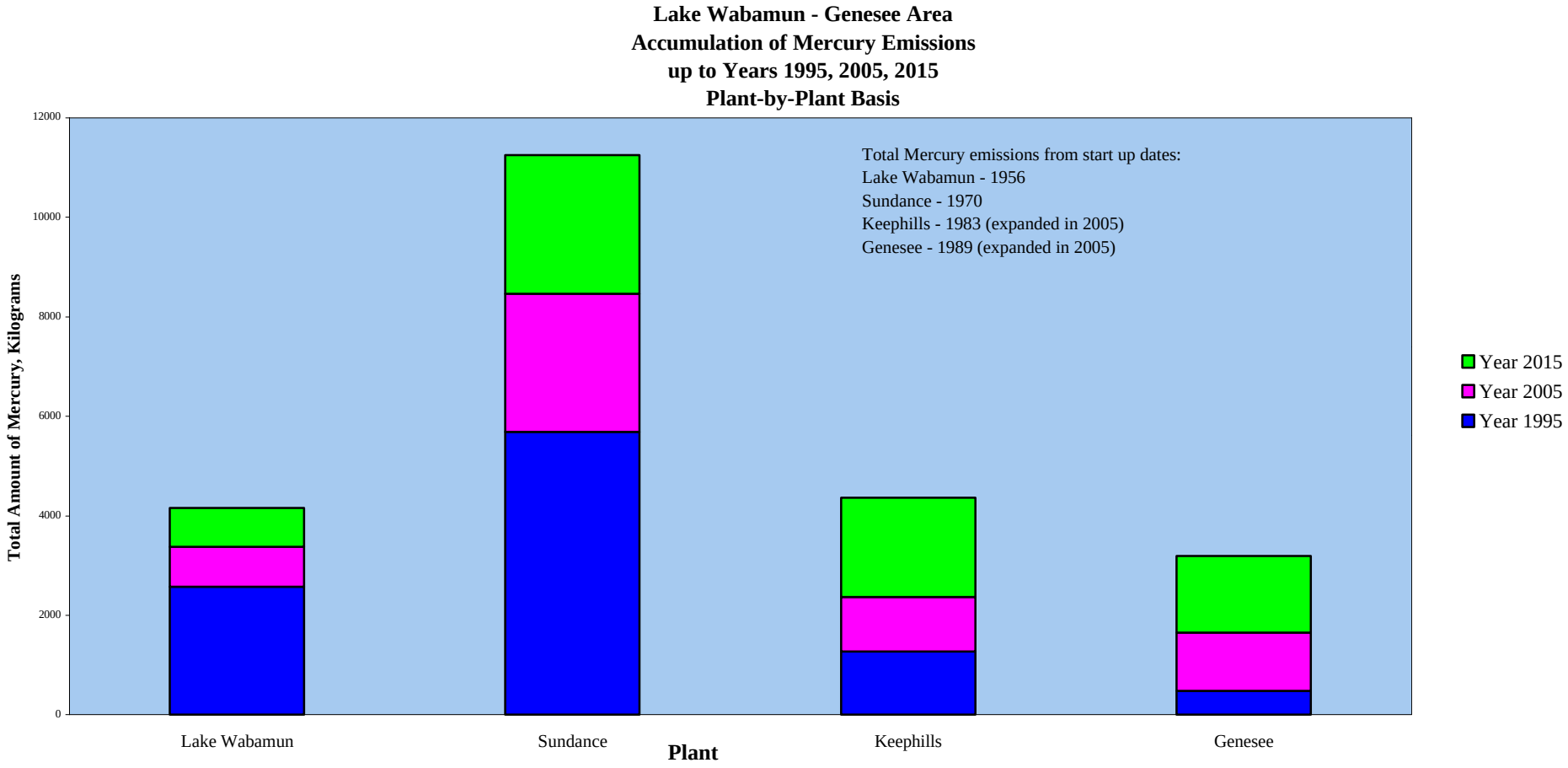
Scenario A: BAU - Business As Usual - no expansion, no additional mercury controls
Scenario B: EXP - Expansion in 2005 - no additional mercury controls
Scenario C: 50/90 (A) - Using Scenario A as base, with prescribed reductions in mercury emissions
Scenario D: 50/90 (B) - Using Scenario B as base, with 50/90 reduction applied as in Scenario C.
50/90 refers to reductions in mercury of 50% in 2007, 90% in 2010 using 1999 as base year.

Figure 5.3 (ii): Cumulative Emissions, Alberta



Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile - A. Tilman, CWS Meetings

Figure 5.3 (iii): Cumulative Emissions, Alberta

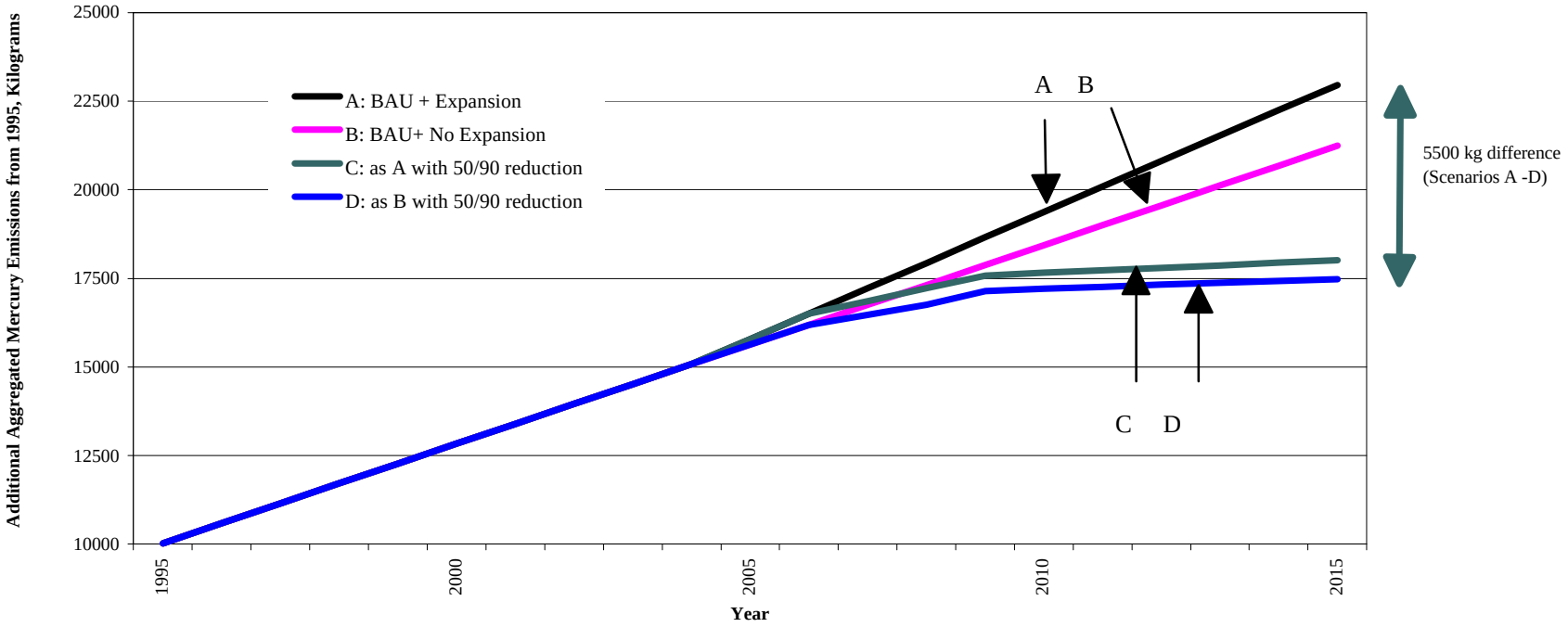


Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile - A. Tilman, CWS Meetings

Figure 5.3 (iv): Cumulative Emissions, Alberta

Cumulative Emissions: Lake Wabamun-Genesee Area (1995-2015)

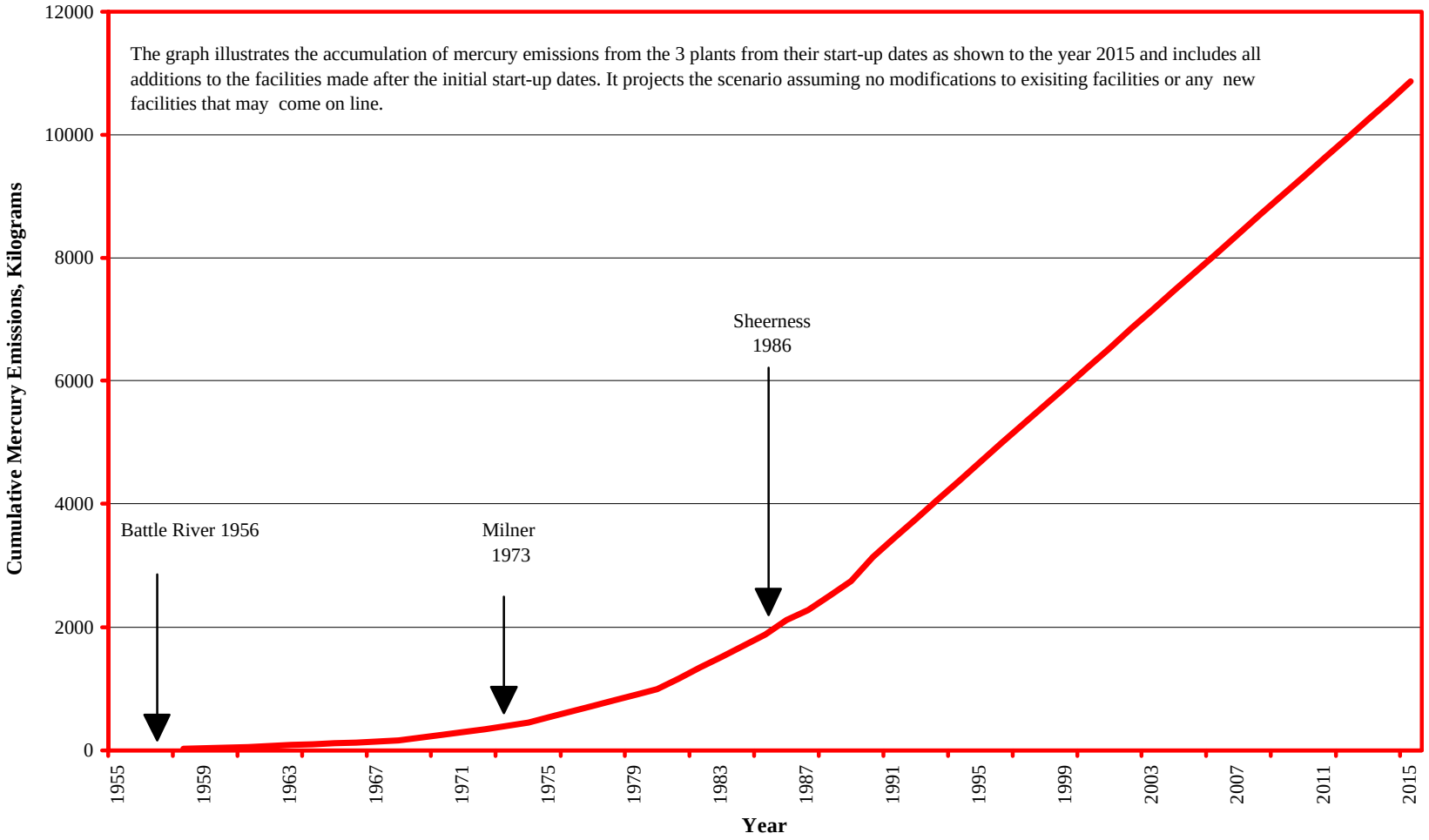
The graph illustrates 4 scenarios for the 4 plants located in the Lake Wabamun-Genesee Area over a 20-year period. Scenario A, Business as Usual (BAU) - no mercury reductions and proposed expansions in place in 2005; Scenario B, as in Scenario A but with no expansions; Scenario C as in Scenario A, but with mercury reductions of 50% by 2007, 90% by 2010, and Scenario D, as in Scenario B but with 50/90 reduction.



Data Sources:
Plant Data - Environment Canada
Mercury Data, Mercury Emissions Profile - A. Tilman, CWS Meetings

Figure 5.3 (v): Cumulative Emissions, Alberta

Cumulative Emissions of 3 Plants:
Battle River, Milner River, Sheerness - ATCO, Alberta (1956-2015)



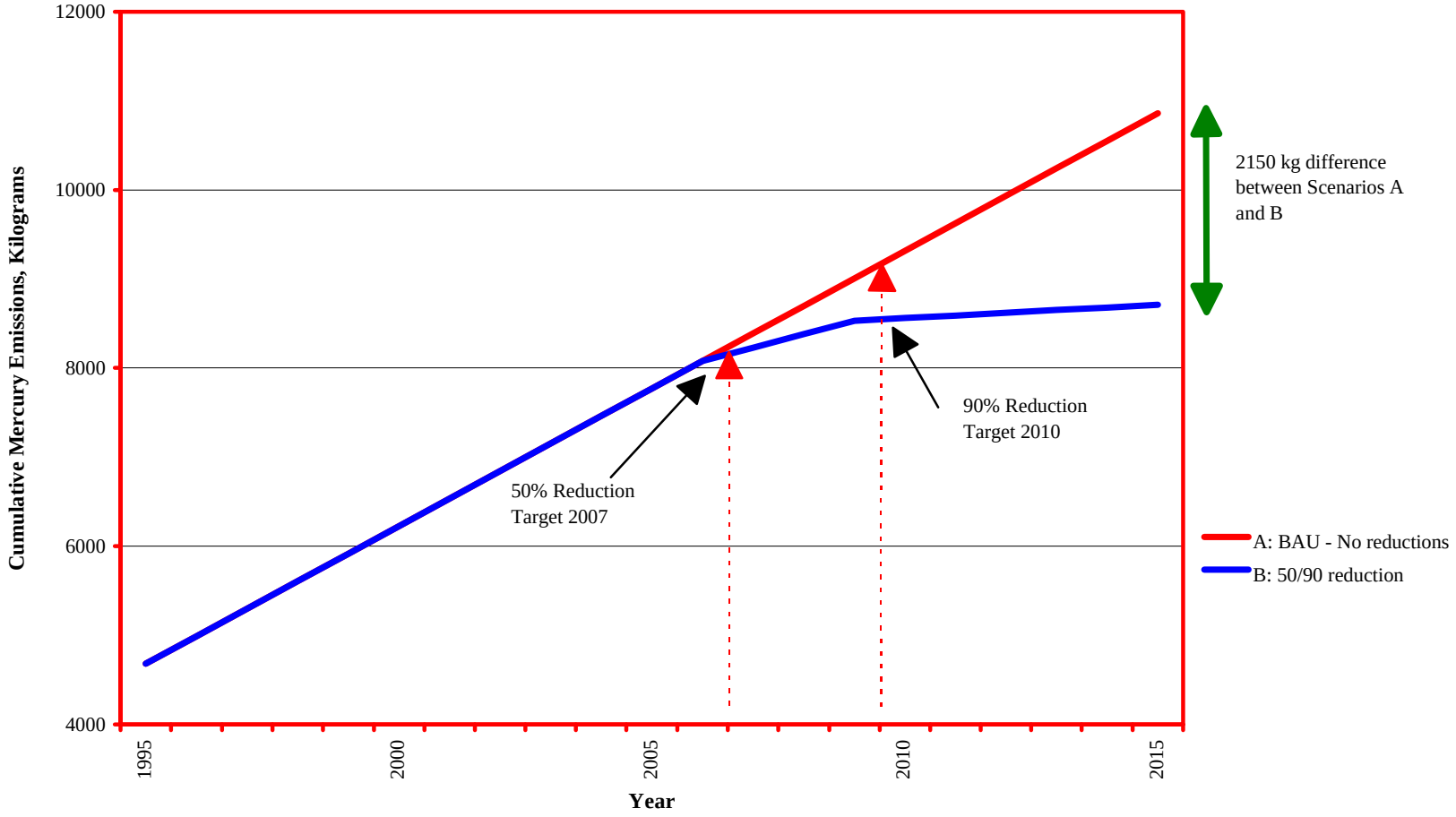
Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile - A. Tilman, CWS Meetings

Figure 5.3 (vi): Cumulative Emissions, Alberta

50/90 Reduction

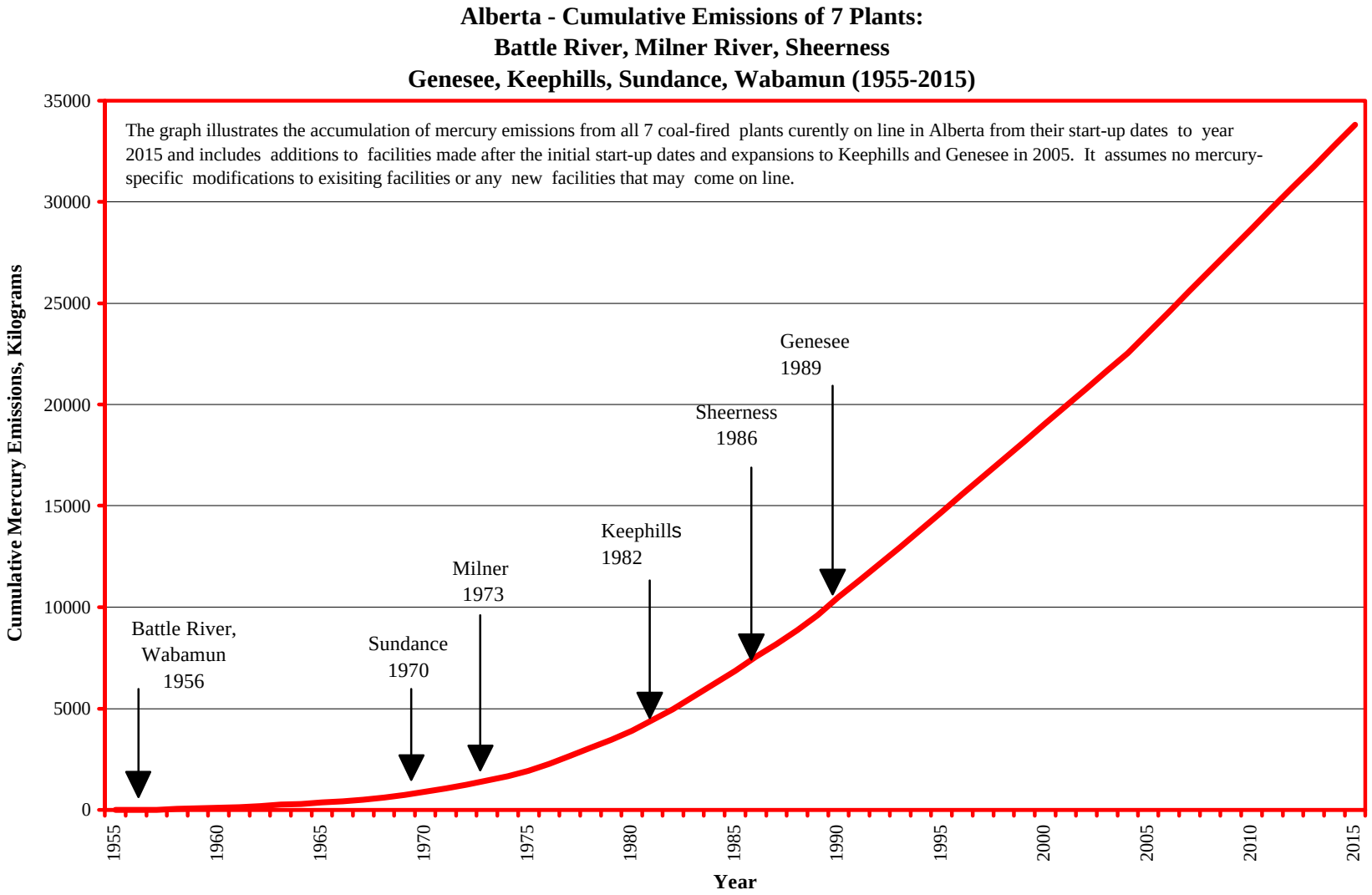
Cumulative Emissions of Three Plants: Battle River, Milner, Sheerness - ATCO, Alberta (1995-2015)

The graph highlights 2 scenarios for the three faci;ities in Alberta over a 20-year period. Scenario A is "Business as Usual - no growth or modifications and no mercury controls. Scenario B reflects a 50% reduction in current emissions in 2007 and 90% reduvction in 2010.



References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

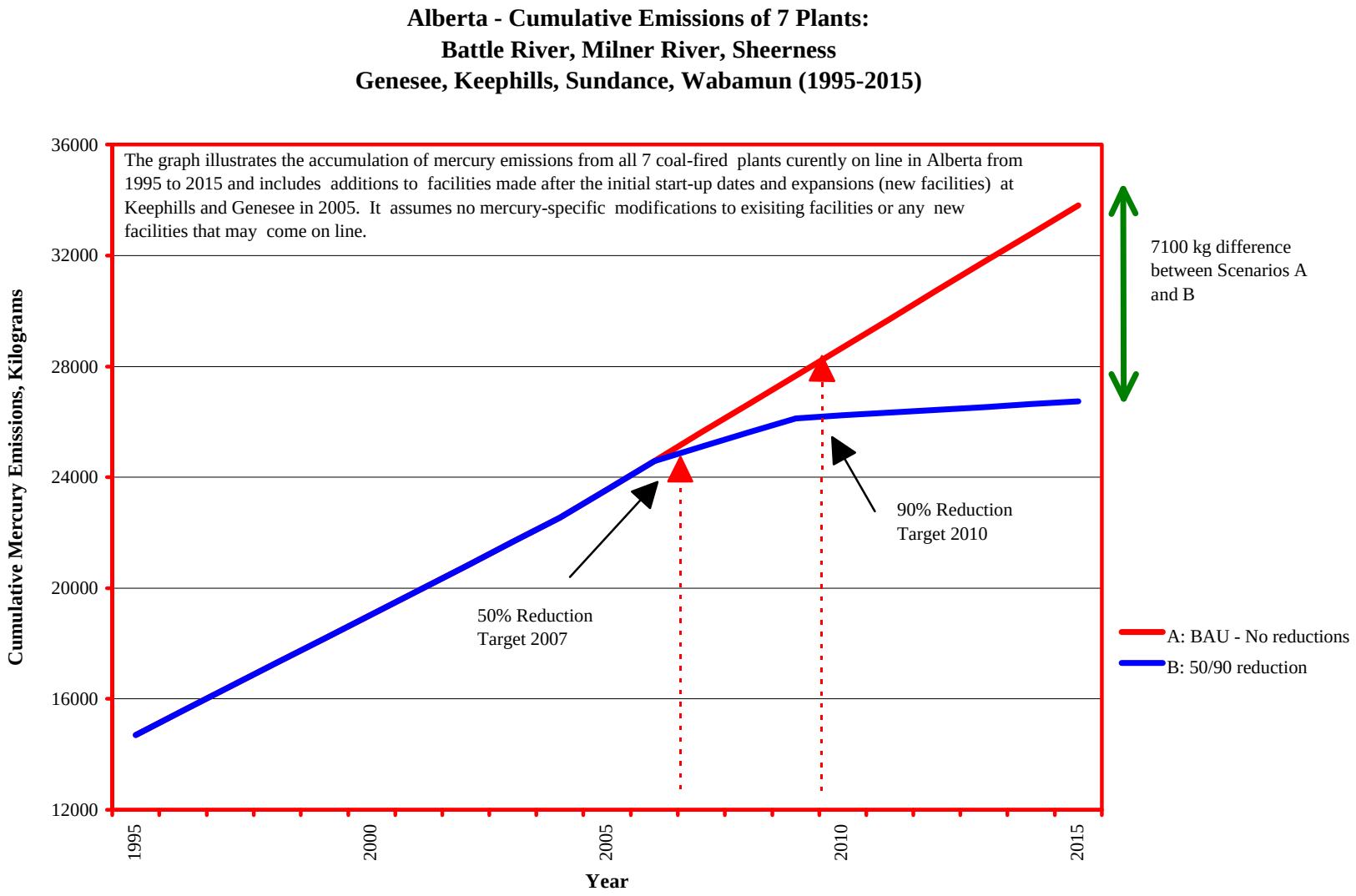
Figure 5.3 (vii): Cumulative Emissions, Alberta



Alberta - Total

References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

Figure 5.3 (viii): Cumulative Emissions, Alberta



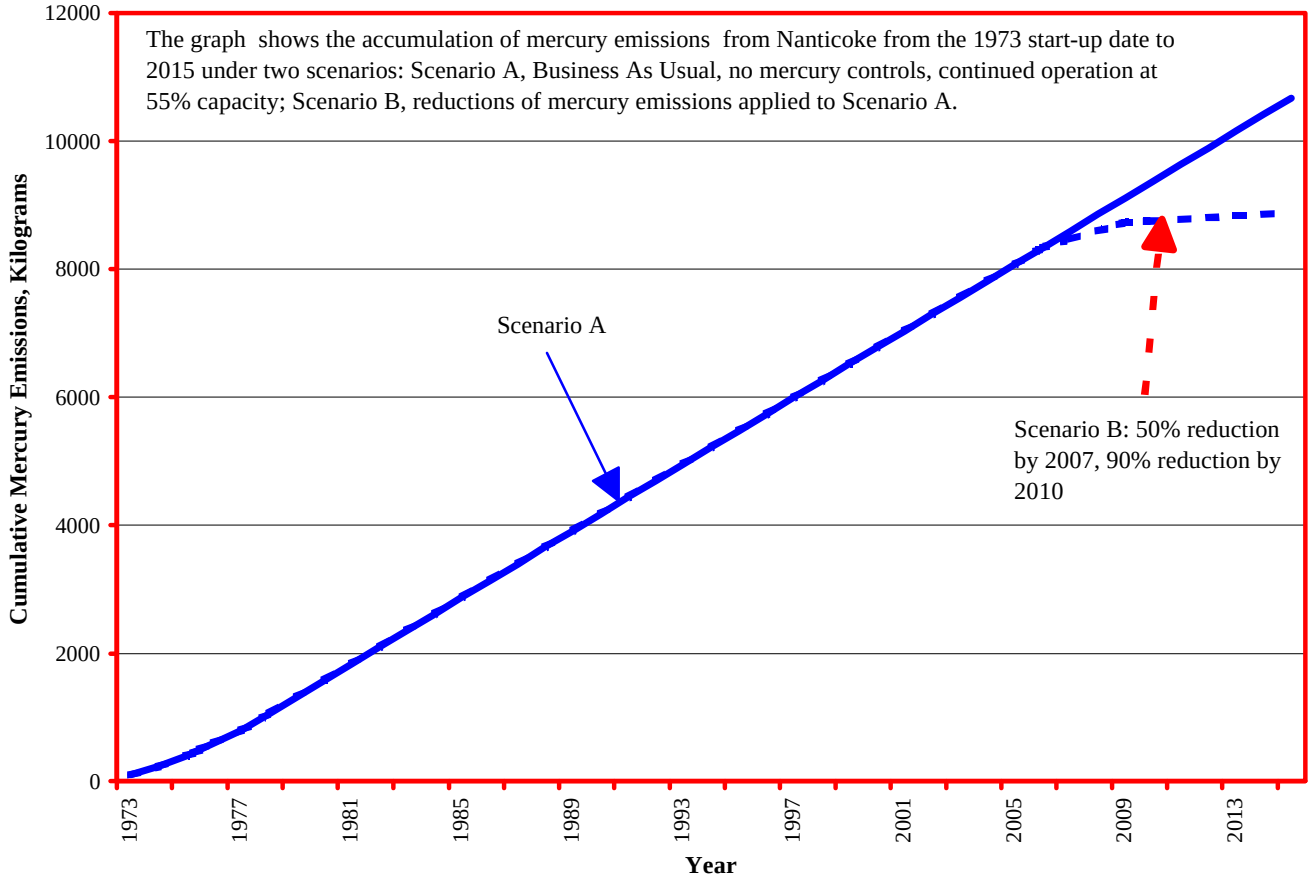
Alberta - Total

References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

Figure 5.4 (i): Cumulative Emissions, Ontario

Cumulative Emissions from Nanticoke Plant
Ontario Power Generation (OPG), Ontario (1973-2015)

The Nanticoke plant, located in Southern Ontario on the shore of Lake Erie, entered service in 1973 with 3 units. By 1978, it was expanded to 8 units to its current capacity of 3920 MW, the largest coal-fired plant in North America. In 1999, Nanticoke generated 18000 GWh of electricity operating at 55% of capacity. The expected book retirement is 2015, but can be expanded beyond that with overhauls and replacements.

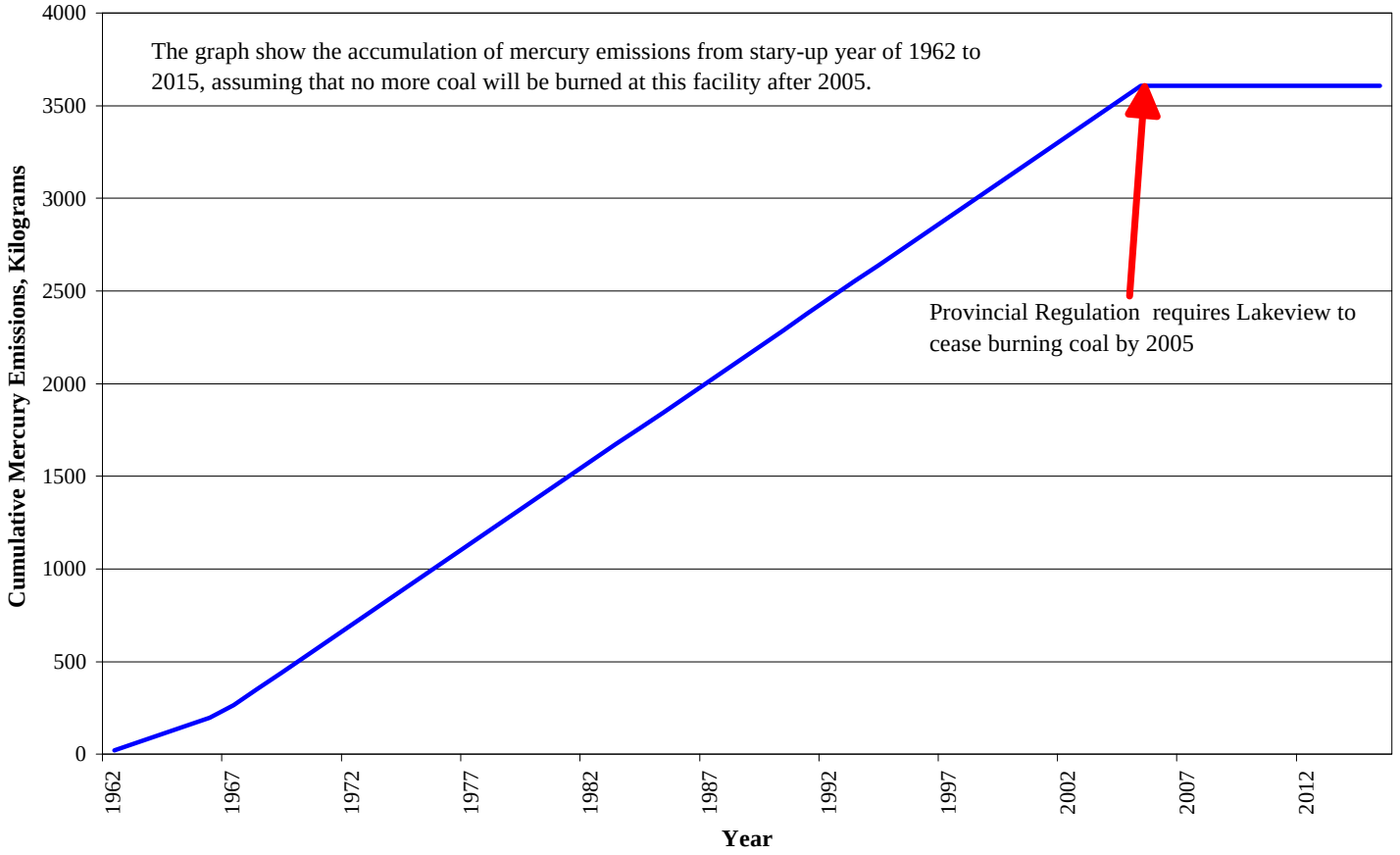


References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.4 (ii): Cumulative Emissions, Ontario

Cumulative Emissions from Lakeview Plant
Ontario Power Generation (OPG), Ontario (1962-2015)

The Lakeview plant, located on the shores of Lake Ontario, is the oldest station in the OPG fleet, entering service in 1962 and expanding to 4 units by 1969, for a total capacity of 1140 MW. Lakeview is the second largest point source of mercury emissions in the Greater Toronto Area. In 1999, Lakeview generated about 3200 GWh of electricity operating at 32 % capacity. While its book life is 2006, it is slated for conversion from coal in 2005.

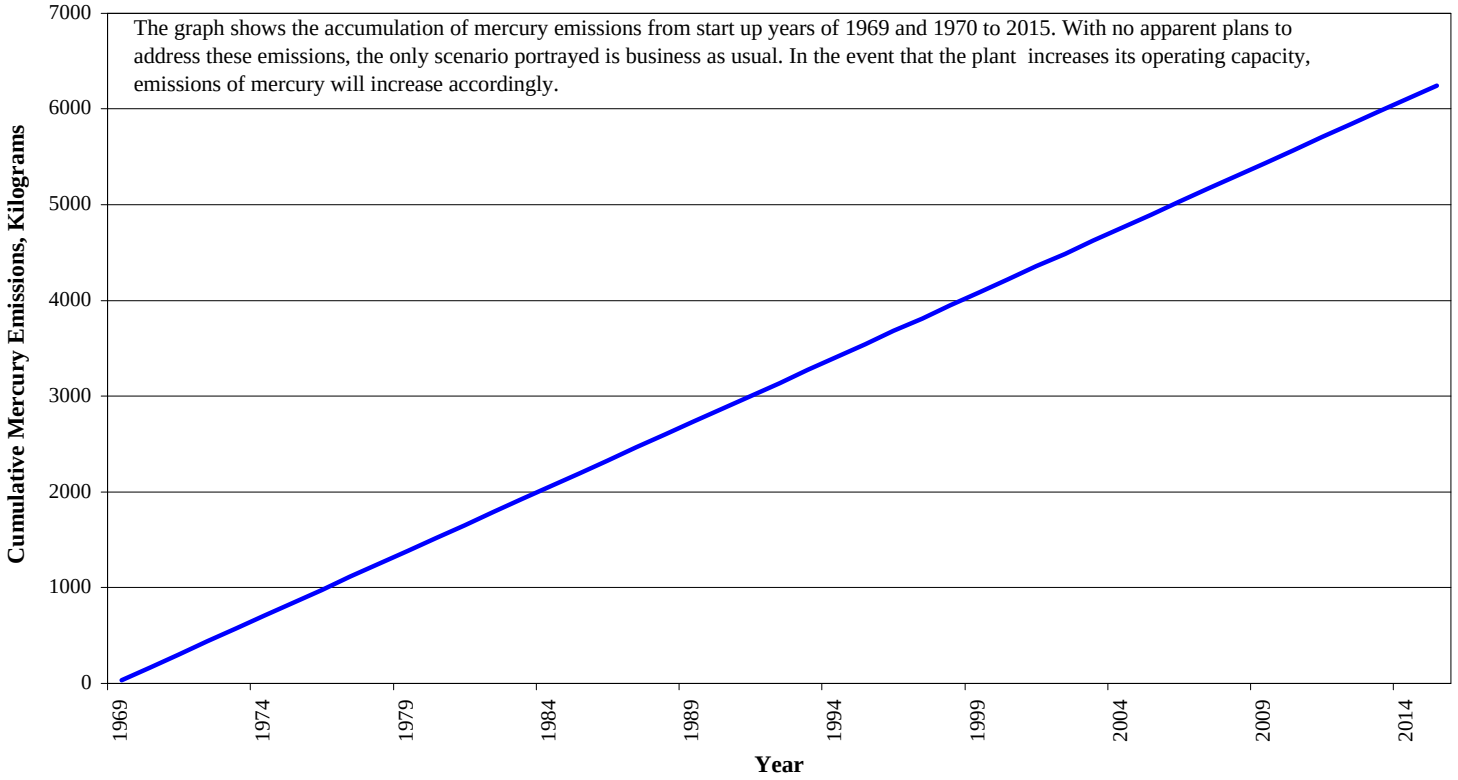


References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.4 (iii): Cumulative Emissions, Ontario

Cumulative Emissions from Lambton Plant
Ontario Power Generation (OPG), Ontario (1969 - 2015)

Lambton, located south of Sarnia on the St. Clair River, entered service in 1969 with one unit and expanded to 4 units in 1970. Its current capacity is 1975 MW. In 1999, Lambton generated 9000 GWh electricity operating at 52% capacity. Lambton is the second largest coal-fired facility operated by OPG and a significant source of emissions of mercury. Two of the units have scrubbers, but not all the units operate to the same degree. The Sarnia area is the location of a large group of chemical industries and on several occasions, emissions from the industrial facilities have lead to unacceptably high pollution levels. The book retirement date of this facility is 2010, but its life can be extended "indefinitely" by overhauls and replacements. OPG has announced plans to install two selective catalytic reduction systems on two units.)

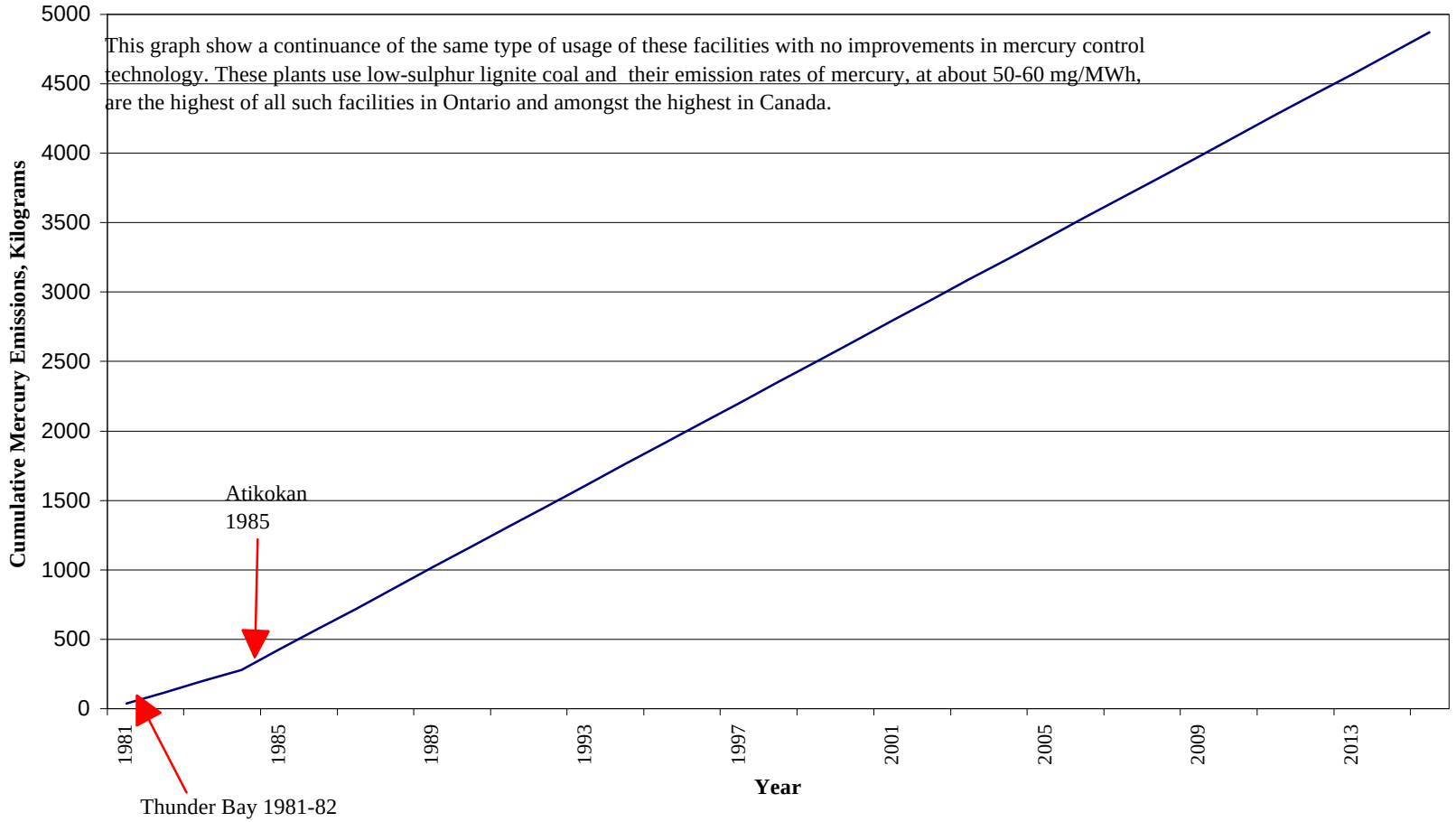


References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.4 (iv): Cumulative Emissions, 2 Plants - Ontario

Cumulative Emissions: Atikokan and Thunder Bay (1981-2015)

Atikokan, located in northwestern Ontario between Lake Superior and the Manitoba border entered service in 1985 with one unit at 215 MW capacity. Thunder Bay has two units, entered service in 1981 and 1982 and has a capacity of 315MW. Both facilities operate at about 59% capacity and generate 1100 and 1600 GWh of electricity respectively.

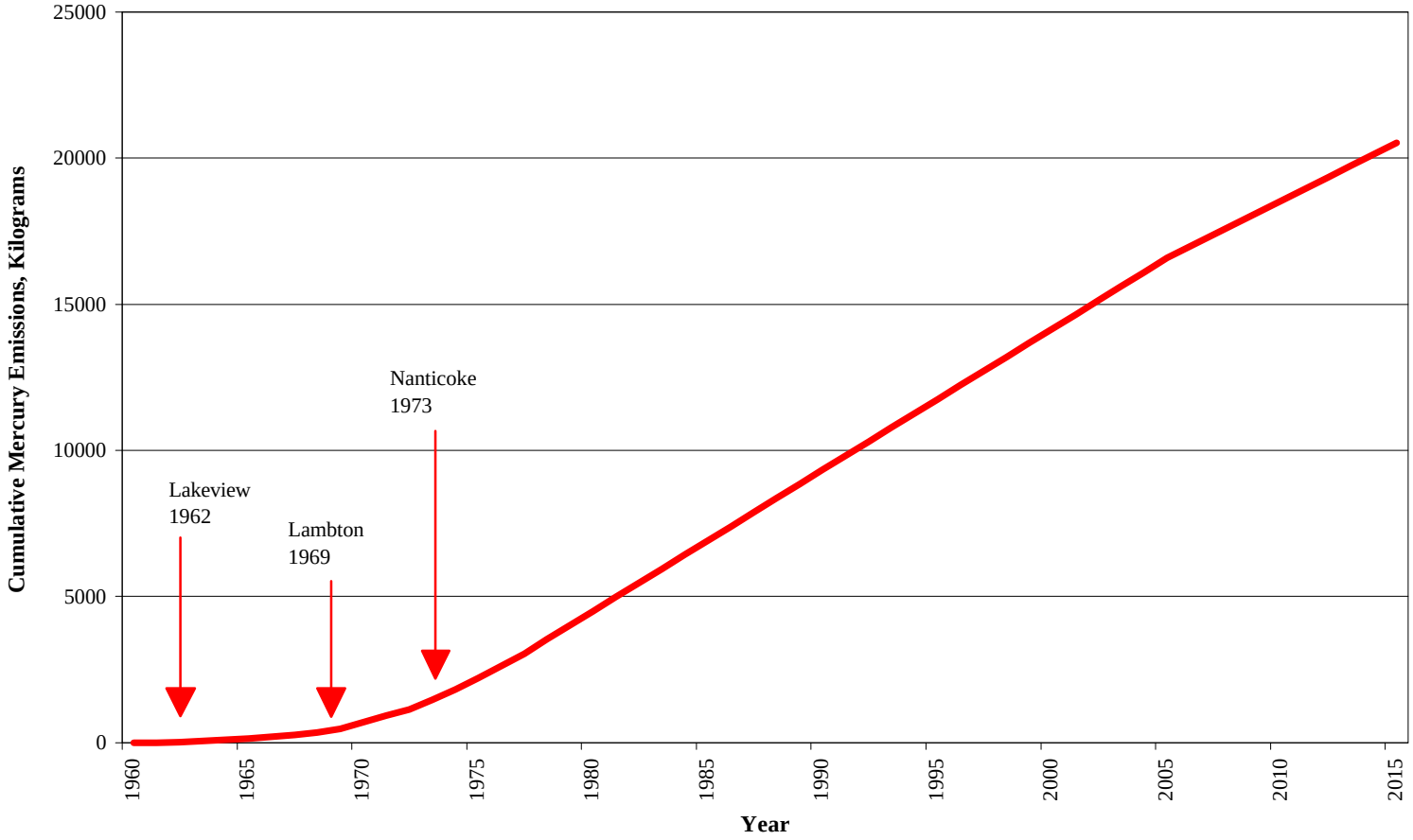


References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.4 (v): Cumulative Emissions, 3 Plants - Ontario

Cumulative Emissions: Lakeview, Lambton, Nanticoke (1962-2015)

The graph illustrates the accumulation of mercury emissions from these 3 plants in the southern Lake Ontario-Lake Erie - St. Clair River Region from their start-up dates to 2015. It assumes that the same level of activity will continue except for Lakeview in 2005. It assumes that Lakeview will not be using coal after 2005. Without any reduction strategy, these units will have emitted more than 20000 kilograms of mercury over this period.

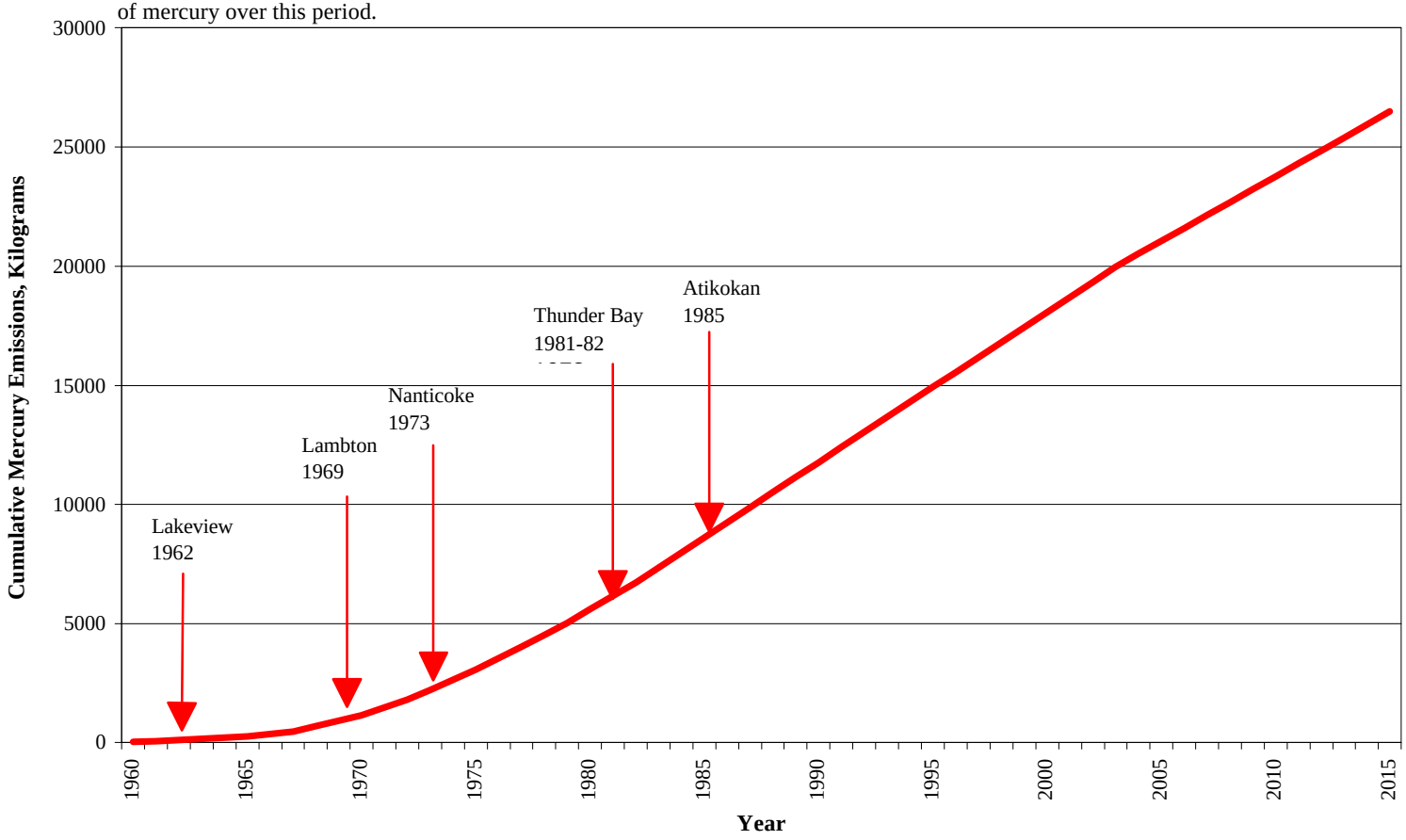


References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.4 (vi): Cumulative Emissions, 5 Plants - Ontario

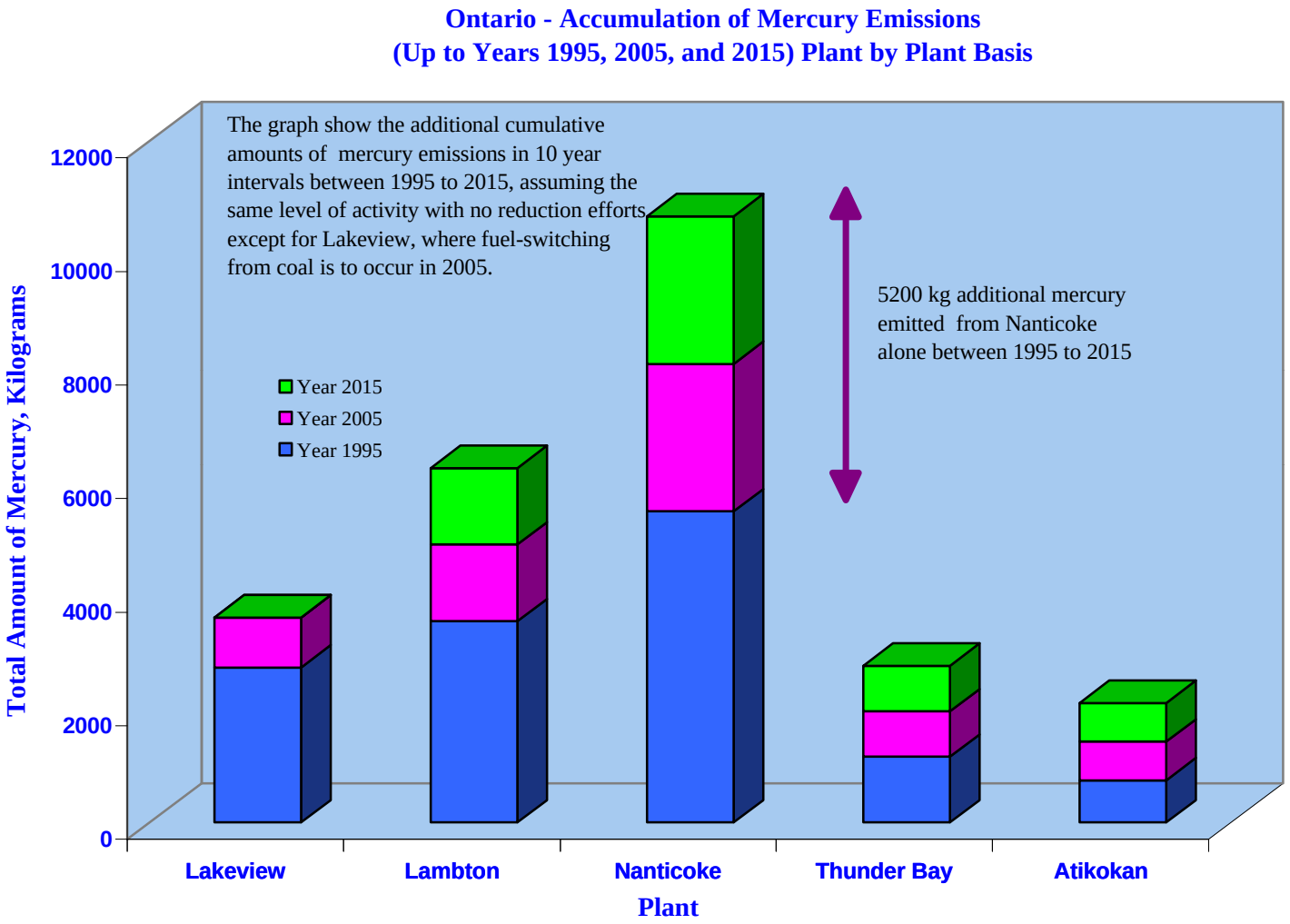
Cumulative Emissions of 5 Plants:
Lakeview, Lambton, Nanticoke, Thunder Bay, Atikokan (1962-2015)

The graph illustrates the accumulation of mercury emissions from the 5 coal-fired plants operated by OPG in Ontario from their start-up dates to 2015. It assumes that the same level of activity will continue, that is similar operation conditions, except for Lakeview in which case coal will not be used after 2005. Without any mercury reduction strategy, these units will have emitted more than 25000 kilograms of mercury over this period.



References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.4 (vii): Cumulative Emissions, Ontario



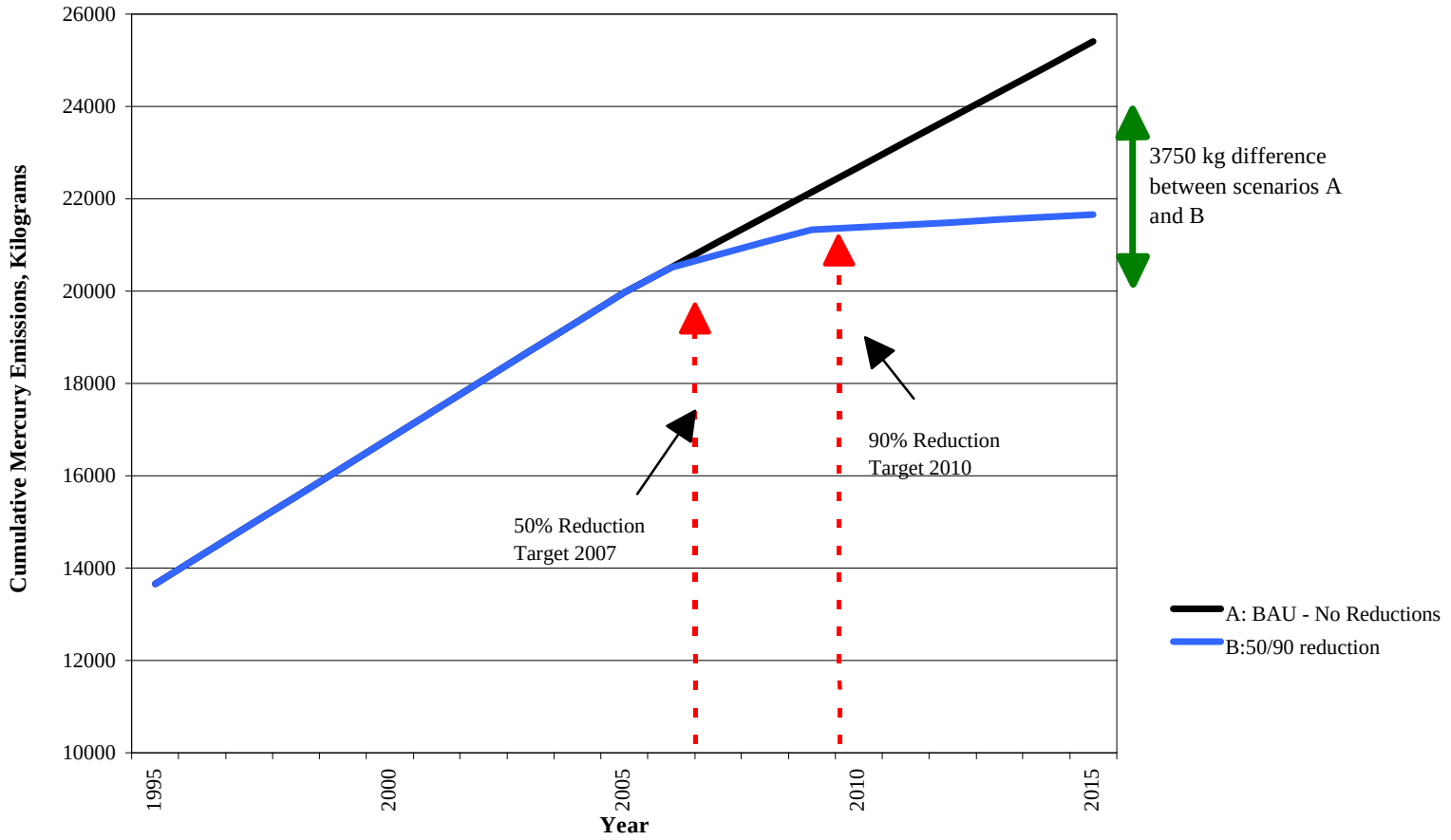
References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.4 (viii): Cumulative Emissions, Ontario

50/90 Reduction

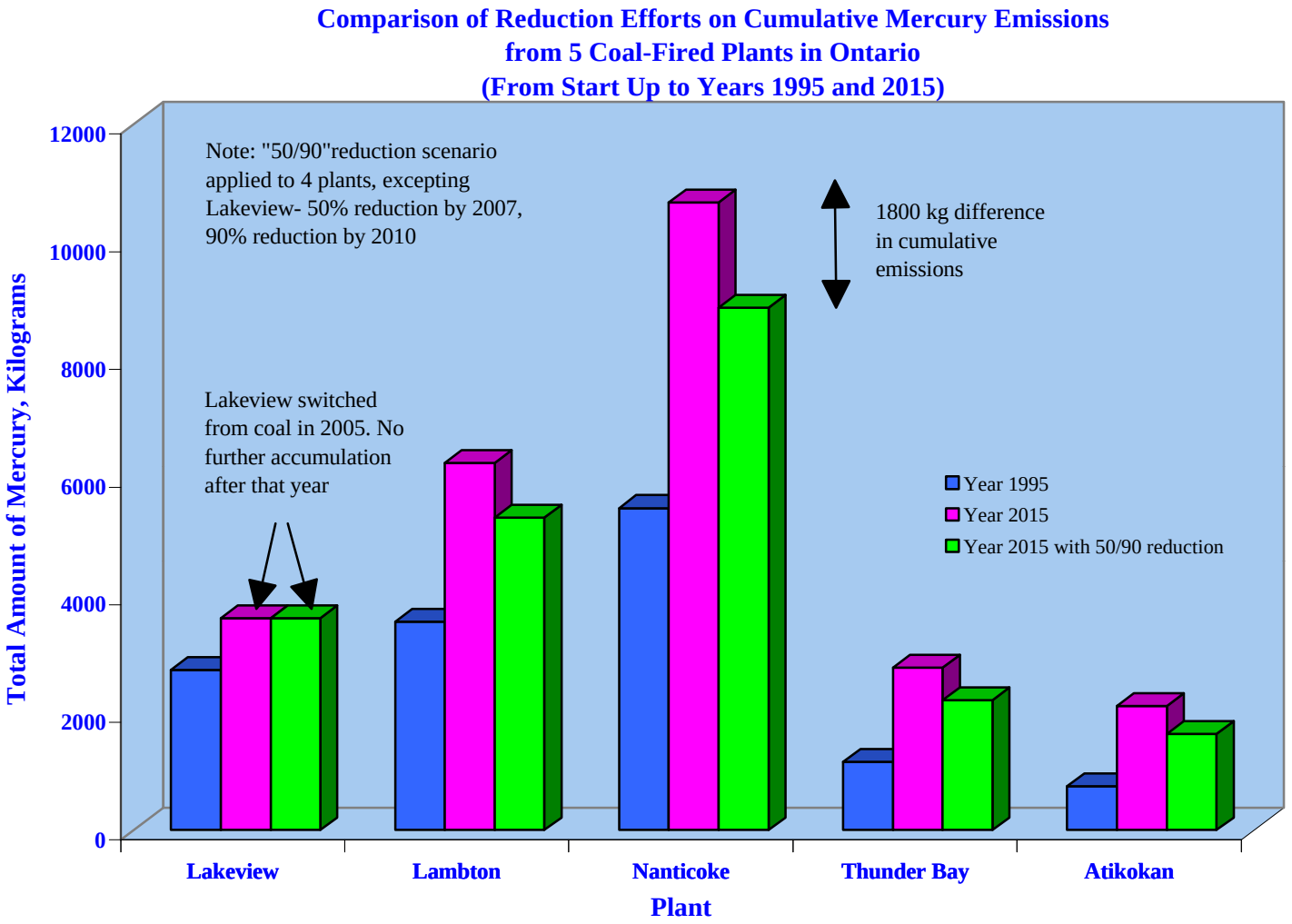
Cumulative Emissions of 5 Plants: Lakeview, Lambton, Nanticoke, Thunder Bay, Atikokan (1995-2015)

The graph illustrates 2 scenarios for the 5 plants in Ontario over a 20-year period. Scenario A: Business As Usual, assuming that Lakeview switches from coal in 2005, Scenario B: reduction in mercury emissions from the remaining 4 plants to 50% in 2007 and 90% in 2010 (based on 1999 emissions estimated total in Canada).



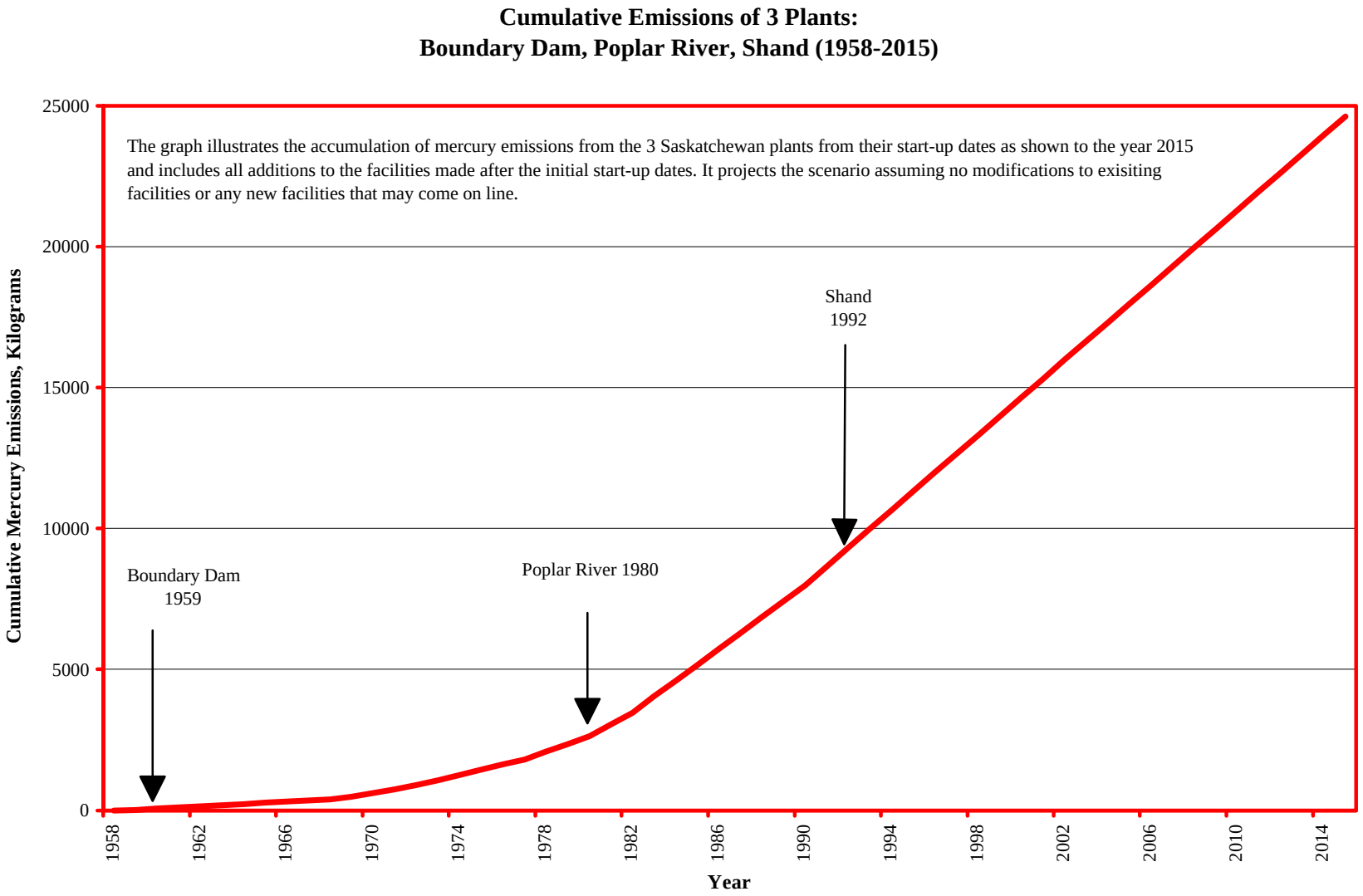
References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.4 (ix): Cumulative Emissions, Ontario



References:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings
"Coal-Fired Electricity in Ontario", March 2001

Figure 5.5 (i): Cumulative Emissions, Saskatchewan



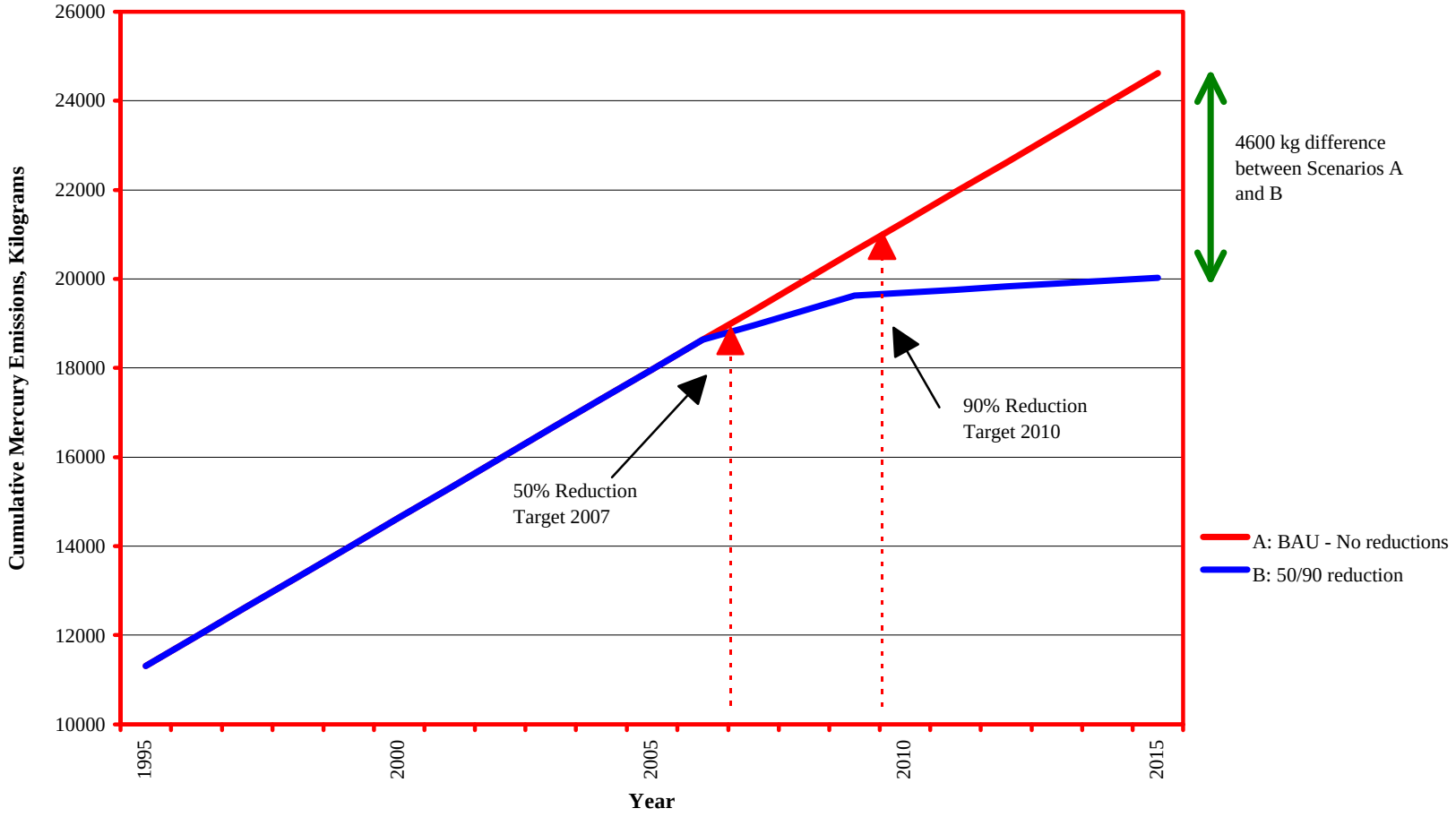
Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

Figure 5.5 (ii): Cumulative Emissions, Saskatchewan

50/90 Reduction

Cumulative Emissions of Three Plants: Boundary Dam, Poplar River, Shand (1995-2015)

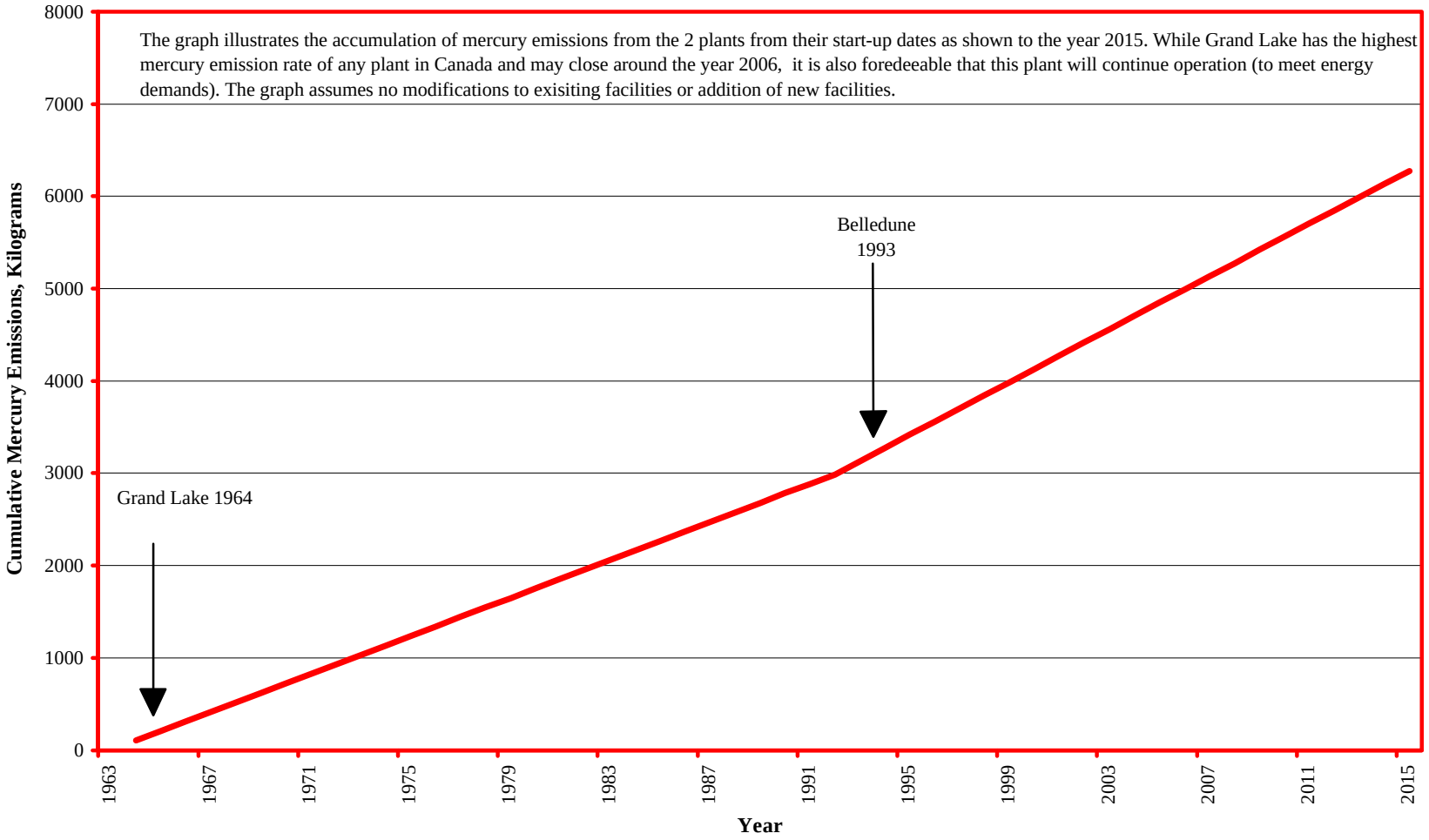
The graph highlights 2 scenarios for the three faci lities in Saskatchewan over a 20-year period. Scenario A is "Business as Usual - no growth or modifications and no mercury controls. Scenario B reflects a 50% reduction in current emissions in 2007 and 90% reduvction in 2010.



Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

Figure 5.6 (i): Cumulative Emissions, New Brunswick

Cumulative Emissions for New Brunswick Plants: Grand Lake and Belledune (1964-2015)



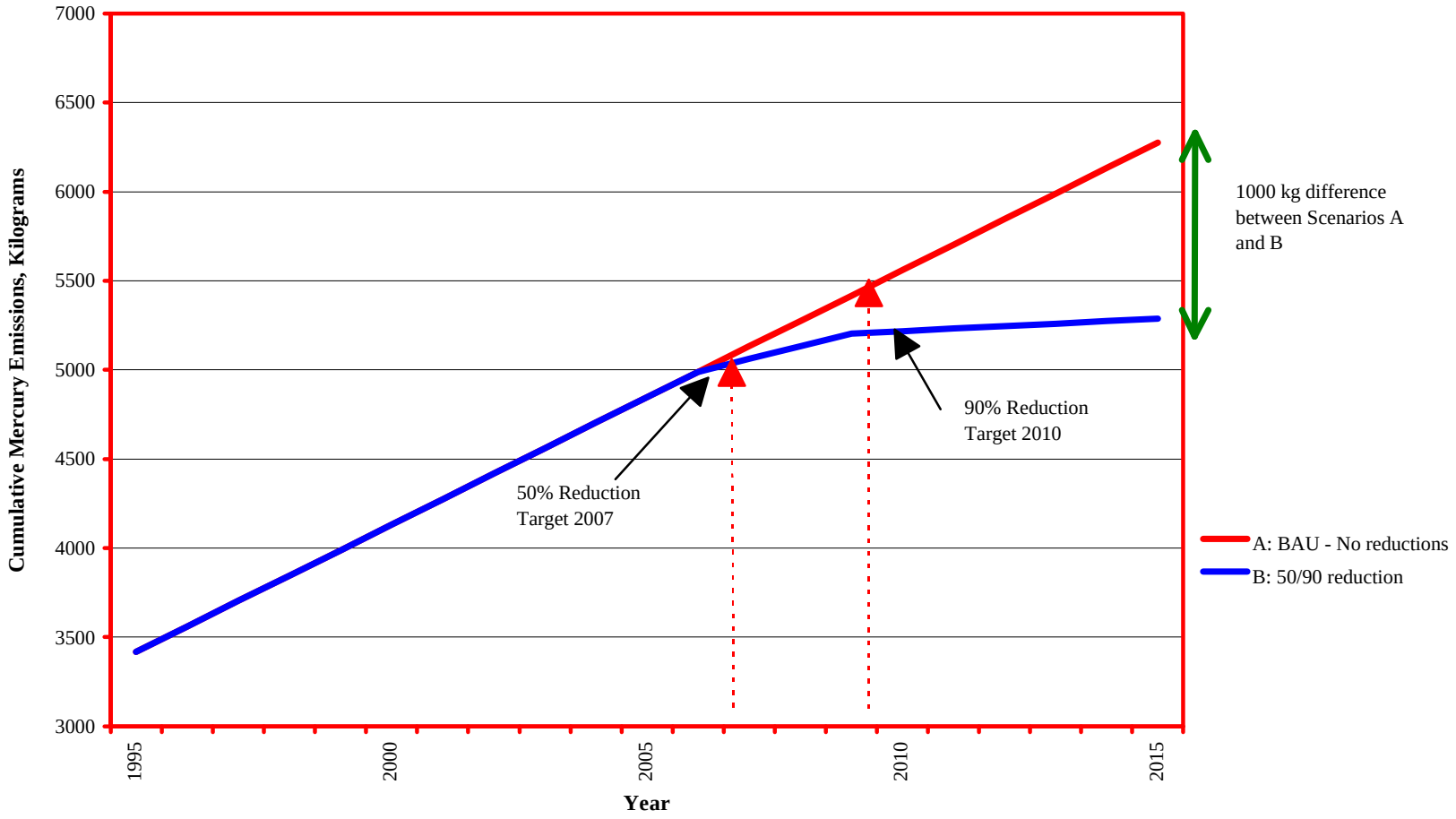
Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

Figure 5.6 (ii): Cumulative Emissions, New Brunswick

50/90 Reduction

Cumulative Emissions of Two Plants: Grand Lake and Belledune (1995-2015)

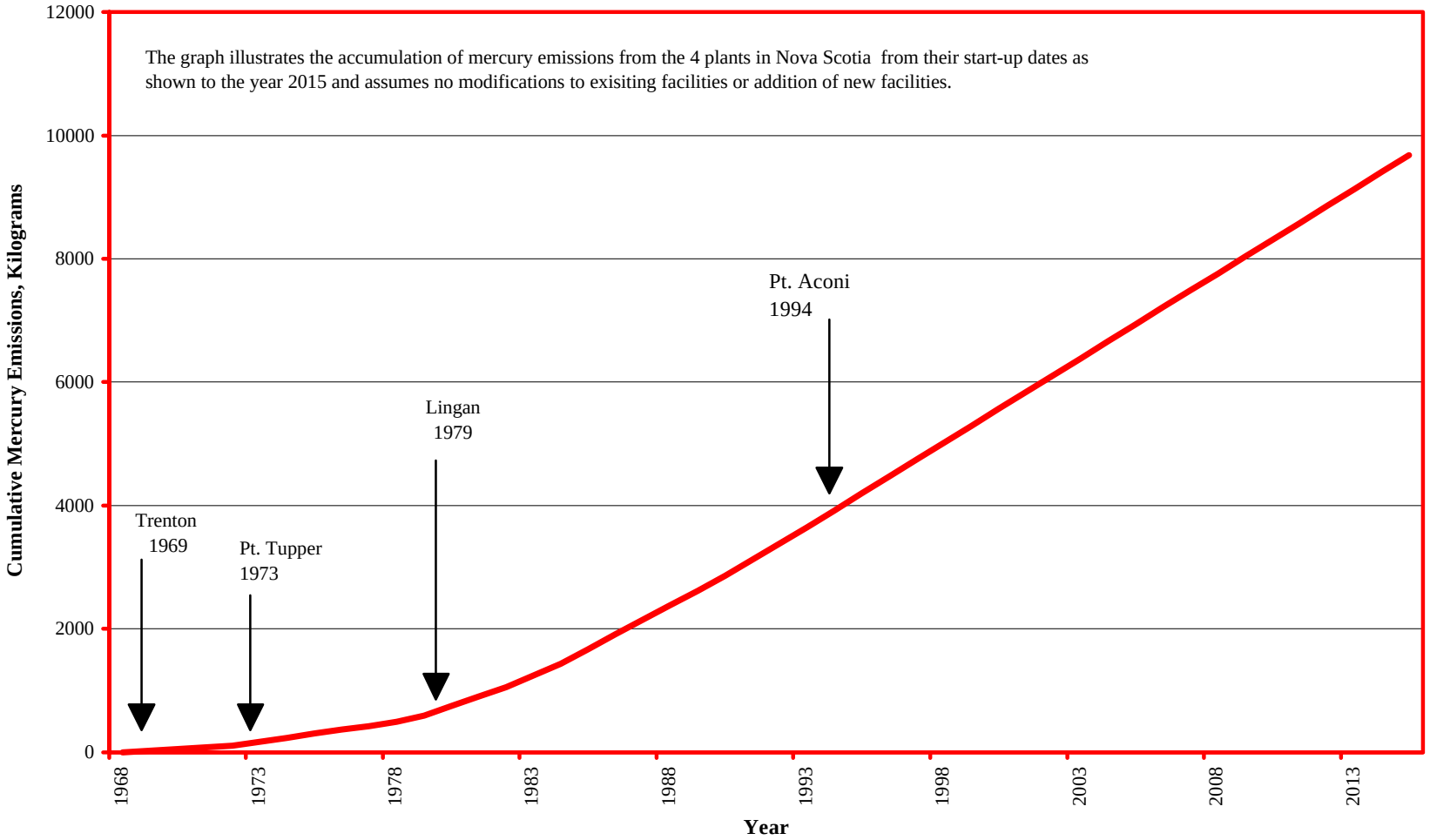
The graph highlights 2 scenarios for the these faci;ities in New Brunswick over a 20-year period. Scenario A is "Business as Usual - no growth or modifications and no mercury controls. Scenario B reflects a 50% reduction in current emissions in 2007 and 90% reduction in 2010.



Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

Figure 5.7 (i): Cumulative Emissions, Nova Scotia

Cumulative Emissions for Nova Scotia Plants: Lingan, Trenton, Point Aconi and Point Tupper (1969-2015)



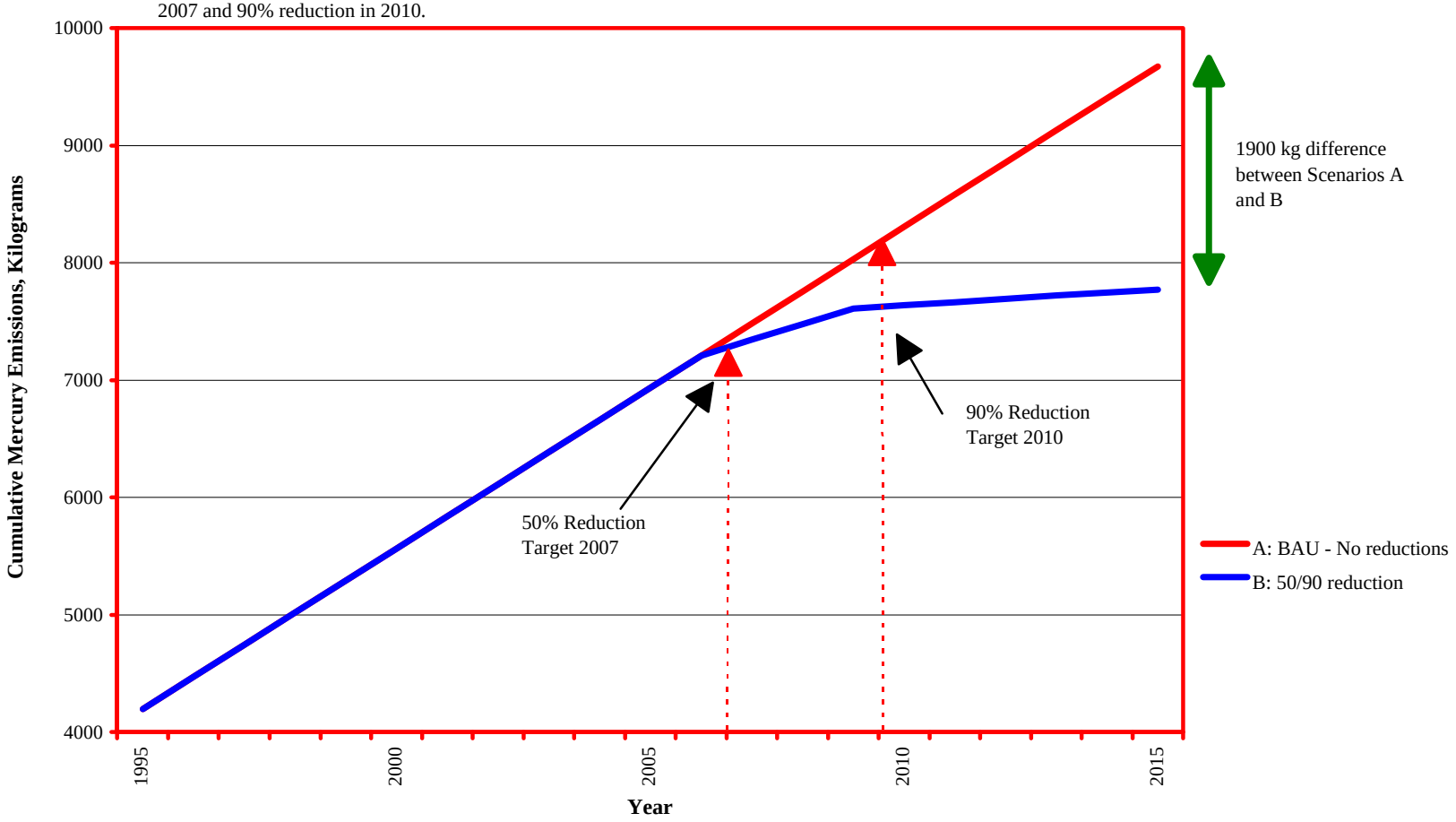
Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

Figure 5.7 (ii): Cumulative Emissions, Nova Scotia

50/90 Reduction

Cumulative Emissions for Nova Scotia Plants: Lingan, Trenton, Point Aconi, Point Tupper (1995-2015)

The graph highlights 2 scenarios for the these faci;ities in Nova Scotia over a 20-year period. Scenario A is "Business as Usual - no growth or modifications and no mercury controls. Scenario B reflects a 50% reduction in current emissions in 2007 and 90% reduction in 2010.



Data Sources:
Plant Data - Environment Canada
Mercury Emissions Profile, A. Tilman, CWS Mercury Meetings

6 United States Regulatory Action on Mercury and Coal-Fired Plants

6.1 Introduction

Coal, the fossil fuel containing the highest amount of mercury, is the most utilized fossil fuel for electricity generation in the U.S. In fact, coal-fired power plants account for 44% of the total electricity production. Collectively, these facilities emit approximately 46 tons (42 tonnes) of mercury each year (based on 1990 estimated emissions). They are the single largest industrial source of airborne mercury in the U.S. contributing about one-third of all U.S. anthropogenic emissions.

The utility sector was granted exemption from regulation until EPA would complete a full review of the sources of mercury and health effects. This sector remains the last major unregulated source of mercury emissions in the U.S.[54] This situation is changing with recent legislative decisions in the U.S. regarding the regulation of this industry.

6.2 Utility Air Toxics Regulatory Determination - Overview

On December 14, 2000, the U.S. Environmental Protection Agency (EPA) announced its decision to regulate emissions of mercury and other air toxics from coal- and oil-fired electric utility steam generating units (power plants)[55]. The EPA is to propose regulations by December 15, 2003 and promulgate final regulations by December 15, 2004. Compliance is expected by December 15 2007.

The basis for the decision comes after several years of gathering and analyzing data on mercury and on other air toxic emissions from oil and coal-fired power plants. Two major reports were instrumental in this decision; the EPA "Mercury Study Report to Congress" (December 1997) which determined that coal-fired plants are the single largest source of mercury air emissions in the U.S. and the Utility Air Toxic "Final Report to Congress" (February 1998) which identified mercury as the Hazardous Air Pollutant (HAP) of greatest concern to human health. Subsequent analyses and other available information further substantiated the need for regulation.

6.3 History of U.S. Action

The basis for the EPA decision to regulate mercury from coal-fired plants is rooted in the U.S. Clean Air Act and comes a full decade after the U.S. Congress in 1990 first directed the agency to begin its analysis of U.S. Mercury emissions.

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[54] Matt Little, Mercury and Power Plants: Can Technology Meet the Challenge? November 2001.

[55] Section 112 (a) (8) of the Act defines electric utility steam generating unit as follows:
The term "electric utility steam generating unit" means "any fossil fuel fired combustion unit of more than 25 MW that serves as a generator for electricity for sale". A unit that co-generates steam and electricity and supplies more than one-third of its potential electrical output capacity and more than 25 MW output to any utility distribution system for sale shall be considered an electric utility steam generating unit.

The US Congress passed the Clean Air Act Amendments (CAAA) in 1990 (referred to as the Act) to further the reduction of air pollution from various industrial sectors. The EPA was directed to categorize and regulate all major sources of Hazardous Air Pollutants (HAP) under Section 112 (n)(1)(A) and (c) of the Act. Mercury is included in the list of 188 (HAP) specified in the Act.[56]

Accordingly, Congress mandated the EPA to carry out a study of the hazards to public health that are "reasonably anticipated to occur as a result of HAP emissions from coal- and oil-fired electric utility steam generating units (power plants)". The results of the study, referred to as " Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units – Final Report to Congress[57] " or utility RTC, were released on February 24, 1998. In its Final Report, the EPA stated that out of 67 air toxics emitted from coal-fired power plants, mercury was the hazardous air pollutant of greatest potential concern and that additional research and monitoring were merited. The EPA also listed a number of research needs related to such mercury emissions that included obtaining additional data on mercury emissions.

In addition to performing the study, section 112(n)(1)(A) of the Act requires the EPA Administrator to regulate HAP emissions from electric utility steam generating units if such regulation is found to be appropriate and necessary after "considering the results of the study". The quoted language is considered to play a principle, but not exclusive role in the decision on regulation. The EPA Administrator is authorized to collect and evaluate any other applicable and appropriate information that would be needed to make an informed decision.

The EPA acknowledged that substantial uncertainties existed that make it difficult to assess mercury emissions and controls and that further research was needed in order to reduce those uncertainties and that the information that would be collected may be used to develop an applicable emission standard [58].

After consideration of the Final Report, the EPA concluded that on balance, mercury emissions from these utilities were of sufficient concern for public health to merit further research and monitoring and that obtaining additional information would be appropriate**. The information would also be made available to the public.**

Following the EPA's February 24, 1998 "Study of Hazardous Air Pollutant Emissions from Electricity Utility Steam Generating Units – Final Report to Congress" (utility RTC), the US EPA made its December 2000 announcement of its finding that regulation of HAP emissions from oil- and coal-fired electric utility steam generating units was appropriate and necessary. As a result of the finding, a project to develop emission regulations under section 112 of the Act began with the crucial timelines of December 15, 2003 for a

[56] Section 112 (n) (1)(A) of the CAAA sets requirement for study in addition to need for regulatory action. Section 112(c) lists source categories, Section 112(b) contains list of substances.
[57] Bill Maxwell, US EPA, Air Toxics Website – Electric Utility Steam Generating Units – Section 112 Rule Making
[58] Information Collection Request for Electric Utility Steam Generating Unit – Mercury Emissions Information Collection Report, Emission Standards Division U.S. EPA Research Triangle Park, North Carolina, November 16, 1998

proposed emission standard, promulgation following on or before December 15, 2004 and compliance by 2007.

The following section presents a summary of the information and conclusions presented in the utility RTC along with other information obtained prior and subsequent to publishing the utility RTC.

6.4 The EPA Health Hazard Assessment

The EPA evaluated exposures, hazards and risks due to HAP emissions from electricity utility steam generating units (oil-, coal- and natural gas-fired). The analysis for mercury was primarily based on information from the **Mercury Study Report to Congress, December 1997.** The report provides an assessment of the magnitude of U.S. emissions by source, the health and environmental implications of those emissions, the availability and cost of control technologies and identifies areas where further research is needed. The report also determined that coal-fired plants were the largest source of mercury air emissions in the U.S.

Based on its assessment of hazards and risks, the EPA concluded that mercury is the HAP of greatest concern. Some of the concerns cited relate to the nature of mercury itself, its toxicity, its multi-media presence, the levels of anthropogenic emissions, and its effect on human health and the environment. Some of the statements highlighting its rationale are given below as context to the U.S. EPA conclusions and its ramifications.

6.4.1 Mercury, the HAP of Greatest Concern - Summary of Text on Rationale

Mercury is highly toxic, persistent and bioaccumulates in food chains. Mercury emitted from power plants (and other sources) primarily in the elemental and divalent form is transported through the atmosphere and eventually deposits onto land or water bodies whereupon it can change into methylmercury, a more highly toxic more bioavailable form that biomagnifies in the aquatic food chain (e.g., fish). Nearly all the mercury that accumulates in fish is methylmercury. Fish consumption dominates the pathway for human exposure to mercury. As of July 20, 2000, 40 states and one territory (American Samoa) had issued fish advisories for mercury.

Neurotoxicity is the health effect of greatest concern with mercury exposure. Ingested methylmercury is almost completely absorbed into the blood and distributed to all tissues (including the brain); it also readily passes through the placenta to the fetus and fetal brain. The developing fetus is considered the most sensitive to the effects of mercury; therefore, women of childbearing age are the population of greatest concern. Also of concern are subsistence fish-eating populations that may be consuming fish from contaminated water bodies.

Children born of women exposed to relatively high levels of methylmercury during pregnancy have exhibited a variety of developmental neurological abnormalities, including delayed onset of walking and talking, cerebral palsy, and reduced neurological test scores. Far lower exposures during pregnancy have resulted in delays and deficits in learning abilities in the children.

Credible studies in humans and animals have indicated that exposure to methylmercury can have adverse effects on the developing and adult cardiovascular system (blood-pressure regulation, heart-rate variability and heart disease) and the immune system.

Most of the mercury entering U.S. water bodies and contaminating fish is a result of air emissions. Approximately 60% of the total mercury deposited in the U.S. comes from U.S. anthropogenic sources, of which coal-fired plants represent about one-third of all such emissions. **Therefore, there is a plausible link between mercury emissions from these facilities and methylmercury in fish. The EPA believes that it is not necessary to quantify the amount of mercury in fish due to coal-fired plant emissions for the purpose of this finding.**

The EPA estimates that about 7% of women of childbearing age (between 15 and 44 years) are exposed to methylmercury at levels exceeding its Reference Dose (RfD) of 0.1 micrograms per kilogram of bodyweight per day (0.1 ✚g/kg/day) and that about 1% of women have methylmercury exposures 3 to 4 times the RfD [59]. These estimates may signify that between 52 000 and 276 000 babies born each year are at risk[60].

Congress directed EPA to request the National Academy of Sciences (NAS**)** to perform an independent study of the toxicological effects of methylmercury and to prepare recommendations for a scientifically appropriate methylmercury reference dose (RfD)[61].

The NAS completed a review of the latest scientific evidence regarding the health effects of methylmercury in July 2000 and affirmed the EPA's assessment of methylmercury toxicity and its reference dose (RfD) of 0.1 ✚g/kg/day. The Academy further noted that children exposed to mercury in the womb as a result of their mothers' diets during pregnancy might be at special risk of neurological problems. In addition, children exposed after birth also are also potentially more sensitive to the toxic effects of methylmercury than adults because their nervous systems are still developing. The NAS estimated that more than 60 000 babies born each year are at risk for neurological developments.

The NAS estimate has been considered to be too low by both the EPA and a recent study carried out by the Centers for Disease Control and Prevention (CDC). As previously mentioned, the EPA has estimated that between 52 000 and 276 000 babies born each year are at risk. Recent data (03/21/2001) from the National Health and Nutritional Survey (NHANES) published by the Centers for Disease Control and Prevention (CDC) indicates that this estimate may be too low in that 10% of women of childbearing age have blood

[59] *Reference dose definition: an estimate of a daily exposure to the human population, including sensitive subpopulations, that is likely to be without a risk of adverse health effects when experienced over a lifetime.*

[60] Based on its estimates that about 7% of women of childbearing age (between 15 and 44 years) are exposed to methylmercury at levels exceeding its RfD of 0.1✚g/kg/day and that about 1% of women have methylmercury exposures 3 to 4 times the RfD. (Ellen Brown, EPA – January 22, 2001 CWS meeting)

[61] Toxicological Effects of Methylmercury, National Research Council (NRC) of NAS, July 2000.

mercury levels that exceed EPA's acceptable limit. This could result in as many as 375 000 U.S. babies being born each year at risk[62].

In its July 2000 report the NAS stated, "because of the beneficial effects of fish consumption, the long-term goal needs to be a reduction in the concentrations of methylmercury in fish". The EPA agrees with that goal and believes that achieving reductions in emissions from coal-fired plants is an important step to achieving that goal.

6.5 Information Collection Request Effort

Among uncertainties cited in the Final Report to Congress were: i) the actual cumulative amount of mercury emitted from these facilities individually and collectively on an annual bases; ii) the speciation of the mercury emitted; and (iii) the effectiveness of the various control technologies in reducing the amount of each form of mercury emitted (including factors such as control devices, fuel type, plant configuration and speciation).

On April 9, 1998 the US EPA published notice of its intention to obtain additional information on mercury emissions from coal-fired power plants in the Federal Register[63]. The EPA submitted an Information Collection Request (ICR) for approval by the Office of Management and Budget (OMB). After input and revision from its initial draft, on or about November 17, 1998, the EPA announced the approval of its ICR (referred to as "Electricity Utility Steam Generating Unit Mercury Emissions Information Collection Effort'') by the OMB.

The intent of the ICR was to gather relevant information on mercury and coal-fired facilities and improve the overall estimate of the amount and species of mercury being emitted form coal-fired utility units. This information along with other studies on health and control option analyses, would serve to assist the EPA Administrator in determining whether regulation of emissions of HAPs by the electricity steam generating units was appropriate and necessary under section 112 of the Act. In the event that regulation would be deemed appropriate, the information being collected might also be used in developing an applicable emission standard and would be made available to the public.

If facilities felt that disclosure of information would compromise a trade secret, such information was to be identified and if determined to constitute a trade secret, would be protected. If no claim of confidentiality is made, the information when received by the EPA is made available to the public. Section 114c of the Act exempts emission data from claims of confidentiality.

[62] National Health and Nutritional Survey (NHANES) Study published by the Centers for Disease Control and Prevention (CDC) March 21 2001

[63] Under authority of Section 114 of the Act.

The ICR effort was conducted over the calendar year 1999 (through the EPA Office of Air and Radiation, OAR).

Following are the three components of the information collection and relevant details.

Part 1 – General Facility Information - All coal-fired utility boilers in the U.S. to be completed once for each plant;

- Facility Name, address, contact information
- What fuels are fired
- Capacity and power sold to distribution systems for coal-fired boilers
- Boiler type, NOx, SO_2 and PM controls

Part I was to be completed and returned to the EPA within 30 days.

Part II – Coal Sampling and Analysis - 1140 coal-fired units;

- Amount of coal received per shipment and for each shipment: Date received, Amount received, Boiler ID#, Coal source (State, County, Seam), Contract verification sample ID# and Coal shipment Method
- Mercury and chlorine content of coal every 6^{th} shipment
- Facilities at mine site
- Statistical confidence
- Evaluate confidence interval every quarter for one year

For each coal sample, facilities are to provide:

- Total amount of coal represented by sample (tons)
- Total sulphur (%)
- Heating value (Btu/lb)
- Ash (%)
- Mercury (ppm)
- Chlorine (ppm)
- Sampling/Supplier Information
    - Name and address of coal supplier and laboratory performing analysis
    - Sampling method - Sample preparation and analysis method
    - Evidence of accuracy and precision
    - Copies of any analysis (where already available) for complete proximate and ultimate analyses and additional trace metals mineralogy of ash

Part III – Speciated Mercury Emissions Testing Data (requirement to conduct speciated mercury stack testing for a selected group of boilers ~ 85 units tested);

- Testing performed at selected sources on a "one-time basis"
- Test plan submitted to EPA for review and approval
- Tests use the Ontario Hydro (OH) Method
- Three separate runs at each sample location measuring inlet and outlet concurrently with concurrent coal sampling during each test period
- Submit test report - Completion – May 31, 2000

6.6 Mercury Emissions Data

In developing the 1998 Utility RTC, the EPA examined data from various sources and estimated mercury emissions to be 46 tons in 1990, 51 tons in 1994 and a projected 60 tons in 2010 from 1026 units at 426 coal-fired plants[64]. By using the ICR, the EPA was able to obtain data from each coal-fired electric utility unit that updated and refined information on mercury emissions from these units. Revised estimates indicate emissions were 43 tons (39 tonnes) of mercury in 1999 from 1149 units at 464 coal-fired plants

The quality of the 1999 data is considered to be significantly better than the data reported in the RTC because of additional information that was collected as opposed to simply emission data alone.

6.7 Measures to Reduce Mercury Emissions

The information gathered by the ICR was utilized in assessing the feasibility and cost of achieving mercury emission control and reduction options.

i) Coal - Usage, Type and Relative Mercury Emissions - 1999 data

Coal Type	Per Cent Total Burned	Per Cent Mercury Emitted
Bituminous	56	52
Sub-bituminous	36	36
Lignite	7	9
Other (e.g. waste coal)	1	3

- Total amount of coal burned: 768 487 000 dry tons
- Total mercury content in coal: 75 tons
- Total mercury emitted to atmosphere: 43 tons

ii) Mercury Speciation and Emission Profiles

Mercury in the flue gas may be present in three forms called species – elemental mercury, Hg^0, divalent (ionic) mercury Hg^{++}, and particulate mercury Hg_{PM} (mercury adsorbed onto the surface of fly ash and other particles). The capture of mercury is highly dependent on the relative amount of mercury species present in the flue gas. Hg_{PM} can be easily removed from conventional Particulate Matter (PM) emission control devices such as Electrostatic Precipitators (ESP) and Fabric Filters (FF). Ionic mercury is generally water-soluble and can be captured in wet scrubbers, such as wet flue gas desulphurisation systems. (90% of ionic mercury can be removed – which may represent anywhere from 20 to 80% of the total mercury). Elemental mercury is insoluble in water and cannot be captured in wet scrubbers.

[64] Estimates of mercury emissions from other sources for 1999 were in the order of 48 tons for 464 coal-fired plants.

Mercury content of coal is not an indicator of the level of mercury emissions in all cases. The **type** of coal is an indicator of speciation mix. Of the 43 tons of mercury emitted in 1999, 43 % was ionic, 54% elemental and 3% particulate form. Bituminous coals emit relatively more ionic mercury from boiler to controls whereas sub-bituminous and lignite coals emit relatively higher elemental mercury. Waste anthracite and bituminous coals emit more than 99% of particulate mercury. The variability in such data may be related to the chlorine content of coal.

iii) Emission Reduction Options

In general, potential strategies available to reduce or eliminate power plant emissions of mercury (and other HAP emissions) include:

- Pre-combustion controls such as fuel switching, natural gas co-firing, coal-switching and coal cleaning
- Conventional existing control technologies such as combustion modification methods to control NOx emissions and flue gas cleaning technologies to control emissions of PM, NOx, and SO_2.
- Developing Technologies Mercury-specific technologies
- Avoidance of emissions - pollution prevention, energy conservation, demand-side management

The EPA has studied the relative effectiveness of these options and cost implications.

iv) Current Status and Effectiveness of Mercury Capture

Mercury emissions reductions are being achieved now as a result of effectiveness of current SO_2, NOx and PM controls, not dedicated mercury controls. Approximately 43% of mercury is being captured on a national scene, that is, out of the potential 75 tons/yr in coal currently, 43 tons/yr are being emitted. There is a very notable variation in mercury capture by existing equipment in specific units anywhere from 0% (essentially no capture) to 90%.

The degree of mercury capture depends on the form of mercury emitted - elemental, ionic, particulate, coal type and flue gas temperature amongst other parameters. The type of coal is a very significant in the effectiveness of mercury capture in particular with reference to the type of control devices. While there is moderate to good capture of bituminous coal, sub-bituminous coals and lignite represent the greatest challenge and to date exhibit poor capture.

v) Effect of Existing Control Technologies (for PM, SO_2 and NOx)[65]

Note: The effectiveness refers to the changes in the amount of the particular species of mercury. This in turn has implications on the amount of mercury captured.

Control Technology	Effect on Oxidized Mercury	Effect on Elemental Mercury	Effect on Particulate Mercury
Electrostatic Precipitators (ESP)	Little, if any	Little, if any	Efficient removal
Fabric Filter (FF)	Adsorption on fly ash (western fuel) Decrease due to oxidation in some instances	Adsorption on fly ash with high amount of unburned carbon Decrease due to oxidation in some instances	Efficient removal
Flue Gas Desulphurization (FGD)	Efficient removal	Little if any removal Increase due to reduction of adsorbed oxidized mercury in some cases	No effect
Selective Catalytic Reduction (SCR)	Increase due to oxidation	Decrease due to oxidation	Increase in some cases
Selective Non-Catalytic Reduction (SNCR)	Unknown	Unknown	Unknown

vi) Existing Emission Controls (PM, SO_2 and NOx) -Observations

- Capture associated with Particulate Matter (PM) controls ranked from best to worst: Fabric Filters (FF), Electrostatic Precipitators (ESP), PM scrubber and mechanical collector.
- Wet (Flue Gas Desulphurization) FGD Units are capable of 90% removal of ionic mercury.
- NOx controls may enhance the ability to capture mercury. Ammonia used in SCR and SNCR oxidizes elemental mercury and converts it to ionic form
- Data indicate that FGD and SNCR are capable of 95% removal (long-term)
- Wet FGD ranged from 33% sub-bit to 96% bit removal.
- Dry scrubbers ranged from 3% sub-bit to 98% bit removal.
- SNCR+CS-ESP (Selective Non-Catalytic Reduction with Cold-Side Electrostatic Precipitator) and SCR+SDA-FF (Selective Catalytic Reduction with Spray Dry Absorber and Fabric Filter) exhibited 91% and 97% reductions for bituminous coal.
- There is variability in control efficiency data and data gaps.

[65] Table from presentation – Praveen Amar, NESCAUM, CWS Mercury Meeting, Edmonton, June 2001

6.8 The MACT (Maximum Achievable Control Technology) Process [66]

The MACT process being used to develop a proposal and implementation mechanism for regulation of mercury emissions from coal-fired plants is proceeding as follows:

- The Clean Air Act Advisory Committee Working Group, a multi-stakeholder group, is meeting on a regular basis for 1 year.
- Public outreach and communication are part of the MACT process.
- ICR data analyses are continuing for the purpose of establishing a section 112 MACT standard.
- The standard for existing facilities is to be at least as stringent as the average emission limit achieved by the best performing 12% of the sources.
- For new facilities, the standard will be at least as stringent as emissions limit achieved by the best-controlled existing source.
- The emission standard is applicable to each source.

6.9 Conclusions

The analysis of potential HAP control strategies led the EPA to conclude that during the regulatory process, effective controls for mercury and other HAP can be shown to be feasible. Mercury emissions from electrical utilities can be controlled by technologies currently used for SO_2, NOx and PM and further research into combining or augmenting these controls specifically for mercury looks promising.

The application of technologies used to control mercury emissions in conjunction with technologies used to control other pollutants (multi-pollutant approach) can substantially reduce or offset the costs of mercury control. Mercury can be controlled from coal-fired plants at reasonable costs without economic dislocation. In fact, a 1999 EPA study estimated mercury control costs at $2.3 billion annually, which represents only 0.001% of utility industry revenues. The history of NOx and SO_2 controls and their costs have shown that costs decrease over time through regulatory-driven innovations. The trend in mercury control costs can be expected to do likewise.

The numerous findings from the ICR and the reports on mercury and electricity utility steam generating units in the U.S. have provided an enormous amount of information that is made all the more important for its accessibility to the public. As an additional supportive measure, the EPA has lowered the threshold for reporting releases of mercury and its compounds to 10 pounds per year to the Toxics Release Inventory (TRI) as of year 2000 [67]. As a result, these utilities will be reporting mercury emissions to TRI. Both these tools, the ICR and the TRI, will enable citizens to find information about significant mercury emissions in their community and track emissions on an annual basis that has otherwise not been available in the public domain from these facilities.

[66] MACT describes a process used in the U.S. in the development of proposals for regulation of emissions of toxic substances such as mercury.

[67] Canada has done similar reporting requirements (5 kg) on its publicly available inventory, the NPRI (National Pollutant Release Inventory)

References:

1) *Mercury White Paper – US EPA, December 2000*
2) *Fact Sheet – Utility Air Toxics Determination, US EPA December 14, 2000*
3) *Information Request for Electric Utility Steam Generating Unit – Mercury Emissions Information Collection Effort, Emissions Standards Division, U.S. EPA, November 16, 1998*
4) *Utility Air Toxics Study Report to Congress, US EPA Executive Summary February 1998*
5) *Mercury Study Report to Congress – Overview US EPA 1998*
6) *Mercury and Power Plants: Can Technology Meet the Challenge? – Matt Little, November 2001 (From Ban-Hg UN NGO Group)*
7) *Centers for Disease Control and Prevention – National Report on Human Exposure to Environmental Chemicals, Results – Mercury March, 2001*
8) M.P. Berkenpas, E. Rubin, D. Smith. G. Gibbon, Preliminary Cost and Performance Models for Mercury Control at Coal-Fired Power Plants, August 2001.
9) R. Roberson – EPA's Mercury Information Collection Request – AWMA Chicago Mega Symposium, August 2001
10) *National Academy of Sciences – Toxicological Effects of Mercury, July 11, 2000*
11) *Notice of Regulatory Finding on Emissions of HAP from Electricity Utility Steam Generating Units - Federal Register/Vol. 65, No. 245/ Wednesday December 20, 2000*

Material from CCME National Workshops on CWS-Hg

1) *Air Toxics Website – Electric Utility Steam Generating Units Section 112 Rule Making US EPA via William Maxwell, EPA November 27, 2001*
2) *Mercury and the Canada-wide Standard – USEPA Electric Utility MACT Rulemaking, CCME National Workshop November 27, 2001*
3) *Utility Air Toxics Finding – Ellen Brown US EPA Office of Air and Radiation January 22, 2001*
4) *US EPA ICR – September 11 200 Workshop*
5) *Praveen Amar, NESCAUM June 4,5 CWS – Hg meeting Environmental Regulation and Technological Innovation: A Case for Controlling Emissions from Coal-Fired Boilers*

7 Recommendations for Canada-wide Standards for Mercury: Electric Power Generating Sector

7.1 Introduction

The CWS for mercury for the electric power generation sector is due to be presented to the CCME in the spring of 2002, presumably for endorsement. The multi-stakeholder process (via the MAG) embarked upon in 1998 has followed an arduous path and a contentious one at that, from the point of view of an ENGO participant. To date, as of March 2002, no recommendation for the CWS has come forward to the group itself. Therefore, it is no surprise that those of us who have participated in the CWS process (at least the ENGOs) are greatly concerned as to the extent and nature of the recommendations that will come forward to the Ministers.

Throughout the numerous consultations over the past few years on this issue, ENGOs have vociferously put forth the position that the CWS place paramount the protection of human health and the environment. Furthermore, the standard must weigh in the potential for growth of this sector and the ensuing cumulative impacts of mercury emissions not only on an annual basis but also over a period of time. In that regard, stringent standards must be set to apply to existing and new facilities. It is also essential that the standard address the **prevention of releases of mercury** and not focus solely on technological solutions via pollution control.

In that spirit, the author has drafted a recommendation document to be presented to the CCME for consideration and adoption in their deliberations of the CWS for atmospheric mercury emissions from the EPG sector. This particular document represents the evolution of previous recommendation papers that have been brought forward by the author to the MAG and DC over the consultation period.

The document itself sets out a strategy recommended for adoption by the Ministers in the interests of setting national standards that would result in significant reductions of atmospheric mercury emissions from coal-fired plants in Canada in a timely manner and in recognition of Canada's international obligations and commitments. It provides an overview of the health and environmental effects of mercury, a discussion of the contributions of the EPG sector to mercury emissions, proposes an overarching goal and objective of the standard along with specifies timelines and targets and a reporting and review procedure.

The recommendation document has received support from many members of environmental organizations across the country. The following sections of this chapter provide a brief synopsis of highlights of the "recommendation document". The document itself in its entirety is found in Appendix D.

7.2 Synopsis – Recommendation Document Canada-wide Standards (CWS) for Mercury – EPG

Human Health and Environmental Impacts

Mercury in its various forms is an extremely toxic indestructible and persistent substance, a known neurotoxin and fetotoxin, posing a direct threat to human health and wildlife. Exposure to mercury can cause serious neurological and developmental damage that includes loss of sensory and cognitive ability, delayed mental and motor development (walking, talking, hearing and writing), learning disabilities, cerebral palsy, tremors, behavioural changes, reproductive difficulties, birth defects, kidney disease, and death. Recent studies of the toxicological effects of methylmercury in the United States indicate that at least 60 000 babies may be born each year in United States with neurological problems because of in utero exposure to methylmercury [68].

The prevalence of mercury contamination in many lakes and rivers has triggered the need to set guidelines for fish consumption directed to protect the most vulnerable populations, in particular children, women of childbearing age and populations subsistent on fish as an essential part of their diet. The accumulation of mercury in fish populations has far-reaching effects on wildlife at the high end of the food chain. Mercury has been shown to damage their livers, kidneys the central nervous system and is the likely cause of reproductive failure. The most devastating effects are found in embryos and the young.

Electric Power Generation Sector

Coal-fired plants are a major and growing contributor to the levels of mercury emissions in Canada. In 1999 alone, these facilities emitted approximately 2500 kilograms to the atmosphere, approximately 39 per cent of the estimated total of national atmospheric emissions for that year from major sources. A more realistic and disturbing depiction of the loading of mercury into the environment by these facilities would result if cumulative emissions of mercury from these facilities were to be accounted for over the lifetime of their operation. In considering such cumulative impacts, the total emissions over a twenty-year period from this sector are in the order of 50-60 tonnes.

The paucity of information and reticence of the utilities to provide essential information along with the lack of forward movement on this issue continue to be obstacles in the CWS process since its onset more than two years ago. Furthermore, the process has been severely compromised with emerging proposals for new and expanded coal-fired plants.

Obligations and Commitments - Domestic and International

- Canadian Environment Protection Act (CEPA): Mercury is designated a Track II substance, requiring life cycle management to prevent or minimize its release into the environment. The National Pollutant Release Inventory (NPRI) requires

[68] Toxicological Effects of Methylmercury – National Research Council of NAS, July 2000 placed the number of babies at risk at lest 60 000. The U.S. Centers for Disease Control and Prevention (CDC) has published a recent study (March 2001) indicating that the number may be in the order of 375000 babies at risk.

mandatory reporting of releases and transfers for facilities manufacturing, processing and otherwise using more than 5 kg of mercury annually as of 2000.

The 1997 Great Lakes Binational Toxics Strategy (BNS),[69], establishes a process to work toward ***virtual elimination*** [70] of specific persistent bioaccumulative toxic substances, including mercury, from the Great Lakes Basin. The Canadian goal was to seek a 90% reduction in the use, generation, or release of mercury by 2000.

The Mercury Action Plan adopted in 1998 by the Eastern Canadian Provinces and New England Governors states as its goal the virtual elimination of anthropogenic mercury in the region and calls for regional reductions in mercury emissions from identified sources to achieve a 75% reduction in emissions by 2003.

The1998 UN ECE Long-Range Transboundary Air Pollution Heavy Metals Protocol relating to mercury, cadmium and lead, signed and ratified by Canada is seeking 50% reduction from 1990 emission levels 8 years from ratification and the use of Best Available Techniques (BAT). The United Nations Environment Programme (UNEP) is undertaking a global assessment of mercury and its compounds for consideration at an upcoming session in 2003.

The Commission for Environmental Cooperation North American Regional Action Plan for Mercury signed by Canada June 2000 has established as its goal the reduction of mercury to approach natural levels and fluxes in certain environmental media, seeking a 50% reduction in mercury emissions by 2006.

Overarching Goal and Objectives

Whereas mercury in its various forms is a Persistent Bioaccumulative Toxin (PBT), exhibiting neurotoxicity and fetotoxicity, posing risks to susceptible populations, in particular the developing fetus, children, women of child-bearing age, native populations, in addition to plants, fish and wildlife;

Whereas mercury is designated as a Track 1I substance under CEPA requiring life cycle management to prevent or minimize its release into the environment;

Whereas the protection of human health and the environment is the underlying driver and affirmed rationale for setting CWS standards for mercury;

Whereas CWS are to result in significant reductions in emissions of mercury;

Whereas atmospheric mercury emissions from coal-fired plants are a very significant source of such emissions in Canada; and

[69] The BNS is an agreement between Canada and United States in keeping with the objectives of the 1987 Great Lakes Water Quality Agreement (GLWQA).

[70] **Virtual elimination** as articulated by the International Joint Commission refers to **use, generation and release** of such substances by encouraging and implementing strategies consistent with the philosophy of zero discharge.

Whereas Canada is an active participant in international and binational agreements to address significant reductions and elimination of anthropogenic sources of mercury;

The overarching goal is to eliminate the use, generation and release of anthropogenic sources of mercury to the environment in order protect the most vulnerable populations and species of the ecosystem for the present and future generations.

The recommended objective of the CWS for the Electric Power Generating Sector is to seek at least 90% reduction in atmospheric emissions of mercury from all coal-fired plants in Canada by the year 2010, relative to baseline year 1999. This percent reduction is deemed to be equivalent to a "cap" on total atmospheric emissions of mercury from all such facilities of 250 kg for 2010.

Highlights of Specific Features of the Recommended Standard

i) The 90% reduction objective must incorporate all and any such additional facilities that may come on line. Maximum permissible mercury emission rates for new modified and/or expanded coal plants must be set at the most stringent level and apply the year such plants commence operation. Standards for existing facilities must at minimum be as stringent as the target set for 2010 for new plants.

ii) An interim target of 50% reduction is to be achieved by 2007 and is to apply to all jurisdictions.

iii) The recommended baseline as a cap is the 1999 emission level of 2500 kg.

iv) The recommended form of the standard is an emissions rate, expressed as the ratio of the amount of mercury emitted to net generation in mg/MWh. The standard must not be based on "capture rate" [71].

v) Standards, targets and timelines are to be applied to each facility in every jurisdiction with units having higher emissions rates addressed as priority.

vi) While preference is for a uniform standard for all facilities, a range of standards according to coal type or blends could apply as an interim measure but should not apply to new plants.

vii) A **mandatory annual reporting and monitoring protocol** consistent for and applicable to all facilities in all jurisdictions is to be established to include:

- Coal type, blend and source
- Amount of coal burned and heat content
- Mercury concentration in coal (ppm) and total mercury (kg)
- Sulphur and chlorine content
- Total annual amount of mercury emitted (kg) [72] and speciation

[71] Further in-depth explanation of "capture rate" is given at the end of this recommendation document.

- Mercury Emission Rate (mg/MWh)
- Mass balance Analysis of Mercury
- Capacity Factors and Net Generation
- Pollution controls added and prevention measures.

viii) No exemptions are to be allowed for facilities emitting < 5 kg annually.

ix) **"Emissions Trading" is not a consideration for mercury.**

x) All jurisdictional implementation plans and compliance strategies are to be in place by year 2003. Those jurisdictions that regulate thermal electric facilities are accountable for achieving reduction targets consistent with the CWS.

xi) **A pollution prevention (P2) strategy** is to be developed.

xii) "Risk-benefit and cost-benefit analyses" must incorporate health and societal benefits as well as the ensuing avoided costs over the long-term.

xiii) The review of the CWS is to take place in 2005 in a multi-stakeholder forum. Specific components include but is not limited to:

- The effectiveness of the interim targets and timelines and progress to date;
- Emerging mercury pollution control technologies;
- Multi-pollutant, integrated approach to mercury reduction and co-benefits;
- Pollution prevention strategies;
- Efficiency of Coal-Fired Plants in generating electricity;
- Review of monitoring and reporting protocol;
- Review and update of jurisdictional implementation plans;
- Review of existing fleet, for new, modified and/or expanded coal plants, and any further proposals;
- Review of New Source Performance Standards for Coal-fired Plants;

xiv) Facilities are required to supply the appropriate information for reporting, monitoring and review. The information must be publicly accessible.

Recommended Workplan – Critical Dates and Standards

2002: Establish the national objective of the CWS, the emission rate standard to meet the objective and the interim standard for 2007 as follows:

Baseline: 2500 kg annual air emissions (based on 1999)
Objective: 90 % reduction by 2010 – equivalent to 250 kg cap by 2010 to include all facilities

[72] The amount of mercury released through manufacturing, processing and otherwise used) greater than 5 kg must be reported on the NPRI.

Emission rate standard [73]: 1.8 mg/MWh to apply to

i) new facilities - compliance on start-up

ii) existing facilities - compliance in 2010

Ø2007 interim standard: based on 50 % reduction from 1999 levels equivalent to annual emissions of 1250 kg: maximum rate of 10 mg/MWh to apply to facilities existing as of 1999:

2003: Establish a Mandatory Reporting and Monitoring Protocol
Jurisdictional Implementation Plans are to be in place
2005: Review of Standard
2007: Conformance with interim standard
2010: Conformance for all facilities and jurisdictions

Summary

Unless sufficient progress is made toward a robust CWS for mercury air emissions from coal-fired plants by the spring of 2002, it is recommended that Environment Canada invoke appropriate legislation under CEPA to regulate emission rates and limits from these facilities, both existing and new/and modified that would result in 90% reduction in emissions in total by the year 2010 (based on the 1999 mercury emission estimates of 2500 kilograms).

7.3 Discussion of "Capture Rate"

Suggestions on the use of "capture rate" as a base for the CWS for mercury have come forward at CWS workshops. The capture rate refers to the percent of mercury in coal removed or captured by air pollution control devices and hence not released to the air. For example, a 65-70% "capture rate" standard would imply a 50% reduction in air emissions.

Capture rate is not a sound measure for a number of reasons. It conveys a greater reduction, viz., 70%, than is actually realized. It is based on the assumption that about 30% of the mercury is currently being controlled or captured at the national level and not released to the air. This is not necessarily valid. In fact, based on information presented at CWS meetings, the percent "controlled" (capture "rate") is highly variable from province to province and can range anywhere from 0 % (no capture) to about 45% and are to all intents and purposes of questionable reliability.

The following chart is designed to assist in clarification and interpretation of the concept of "capture rate". The chart displays capture and emission rate scenarios using the 1999 atmospheric mercury emissions of 2500 kg and total mercury content in coal of 3600 kg.[74] It is important to understand that a 30% mercury capture rate means that 70% of the total mercury in coal is emitted into the atmosphere.

[73] The emission rates estimated are based on estimates of current emissions and include a 20% safety margin to account for errors and potential increases in generation.

[74] The mercury-in-coal content figure of 3600 kg total was given at CWS meetings. However, this figure in itself is of questionable reliability since information on mercury content in coal is not readily or generally available.

The chart portrays the likelihood of increased "capture" of mercury through air pollution control devices. The potential for increased generation is factored in with the implication that more coal would be burned and hence correspondingly more mercury released.

Mercury Capture Rate versus
Percent Atmospheric Mercury Emission Reduction

Mercury Content in Coal (kg)	Mercury Captured (kg)	Mercury Emitted (kg)	Per Cent Captured %	Emission Reduction %
3600	1100	2500	30	0
3600	**1800**	**1800**	**50**	**28**
3600	2350	1250	65	50
3600	2850	750	80	70
3600	3350	250	93	90
4000	1500	2500	38	0
4000	2750	1250	69	50
4400	3150	1250	72	50

Note that a 50% "capture rate" really signifies a reduction in atmospheric emissions of mercury of only 28%. Considering the likelihood that a margin of error at least 20% exists, one could question whether any real reduction in emissions would have occurred.

Summary of Issues on Capture Rate:

By using capture (rate), the mercury content of coal becomes the baseline by default rather than the air emissions of mercury.

New or modified plants cannot be addressed by this approach.

"Capture rate" combined with "emission reduction percent" result in two different numbers (percents) and could lead to misinterpretation of the standard and its effectiveness.

It is not consistent with the approach taken for other CWS to date.

This approach fails to consider the need to reduce mercury at the source.

To date, facility - specific or province-specific data on capture or mercury-in-coal content is unreliable and not publicly available.

This approach does not fit into a multi-pollutant strategy.

In conclusion, mercury "capture rate" lacks scientific merit. Emission rates are the appropriate sound and acceptable approach to the CWS.

8 Summary

8.1 Conclusions

With human health and the environment as the overriding theme, coal-fired plants, their mercury emissions and the Canada-wide Standards process have clearly been the focus of this document. The legacy of their cumulative emissions of mercury over the lifetime of their operations is considerable.

With what is known to date, governments are in a position to move forward on the standards and deliver a strong message to the industry and the public that they are firmly committed to implement appropriate measures on reducing mercury emissions without any further delay. If the CWS is not to be the primary catalyst, then governments must be prepared to regulate mercury emission rates from these facilities that will result in major reductions of emissions of mercury from this sector. It is their responsibility.

At the same time, the Electric Power Generation Sector and in particular thermal electric (coal-fired) plants loom large on the Canadian landscape. This sector is a very significant source of pollutants that are instrumental in contributing to climate change, acid rain and smog as well as many hazardous air pollutants including mercury. This industry is also in a stage of unforeseen growth in Canada – as the "coal rush" moves into high gear to meet questionable demands in the U.S. and Canada. As proposals for new coal-fired plants come forward, we as a country are remiss in not having the tools and policies in place to harness this unfettered growth. So far, this sector has been successful in staying the course while resisting measures to make them more accountable for the pollution that they cause. The impact on the ecosystem is far too great a price to pay to allow this pattern to continue and proliferate in a seemingly oblivious manner.

In conclusion, the implementation of a stringent mercury emission standard (CWS) for coal-fired plants by all jurisdictions must come about and be closely monitored and reviewed to ensure its conformance and its effectiveness.

Quite likely, the methods chosen to meet the standard may have additional benefits and may result in reductions in other pollutants emitted by these sources. Rather than viewing the standard as an economic burden, as is often stated by industry, it should be viewed as an opportunity, and one of the many initiatives to be taken if we are to seriously address the rising global levels of mercury and the impacts on those most vulnerable.

Given the current chaotic state of the electric power generation sector, the optimistic outcome of imposing standards *may* result in greater application of innovative technological solutions and more effective pollution control devices, increased efficiency of electricity generation, and even more important, conservation of energy, fuel-switching, renewable energy strategies and pollution prevention measures.

8. 2 Recommendations: Mercury in Canada - Potential Issues to Explore

Beyond the specific issue related to coal-fired plants, there are many areas that require effort and attention if we are to alter the trend in increasing anthropogenic mercury emissions. Some of those areas recommended for further study include:

Human Health Impacts: Emphasis on Sensitive Populations – First Nations, Children, Women of Childbearing Age

Review (potentially upgrading) risk factors and the TDI (Tolerable Daily Intake)

Effects of long-term (chronic) exposure

Synergistic effects with other toxic substances (PCBs, lead)

Contamination of Fish - Status of Fish Advisories

Effects on Wildlife

Identification of Geographically Sensitive Areas (known)

Mercury Deposition - Mercury Levels in Rain

Source-Receptor Relationships

Status of Mercury Emission Sources - Inventories

Establishing mercury emission standards for sources

Programs to phase out and/or ban the use of mercury in, for example, Fluorescent Tubes, Instruments, Vaccines, Mercury in Cars (Switches), Dental Amalgam, etc.,

Mercury Removal and Retirement Initiatives

Lighthouses…

While further effort and research is necessary, there is sufficient evidence now of the harm that mercury imposes and the need to significantly reduce the use and release of anthropogenic mercury into the environment and placing resources.

On a final note, it cannot be emphasized enough how important it is to educate the public on the effects of mercury on human health and the environment. Far too little is done in to raise awareness in this area and reduce and eliminate its use despite its very nature that makes mercury rife for just such activities.

GLOSSARY-PART A

Note: This glossary covers terms and abbreviations used in this document as well as other terminology found pertaining to mercury and the Electric Power Generating Sector.

ACRONYMS

ACC	-	Advanced Coal Cleaning
acf	-	actual cubic feet
ACI	-	Activated Carbon Injection
APCD	-	Air Pollution Control Device
BAT	-	Best Available Techniques (U.N. Definition)
BNS	-	Binational Toxics Strategy
Btu/lb	-	British Thermal Units per pound
CAA	-	Clean Air Act (U.S.)
CAAA	-	Clean Air Act Amendments
CAC	-	Criteria Air Contaminants
$CaOH_2$	-	Hydrated Lime
CCR	-	Coal Combustion Residue
CCME	-	Canadian Council of Ministers of the Environment
CDC	-	Centers for Disease Control and Prevention
CEA	-	Canadian Electricity Association
CEF	-	Cost Estimating Function
CEC	-	Commission for Environmental Co-operation
CEMS	-	Continuous Emissions Monitoring System
CEPA	-	Canadian Environmental Protection Act
CFB	-	Circulating Fluidized Bed
CH_3-Hg	-	Methylmercury
CI	-	Carbon Injection
Cl_2	-	Chlorine
CO	-	Carbon Monoxide
COHPAC	-	Compact Hybrid Particulate Collector
CO_2	-	Carbon Dioxide
CS-ESP	-	Cold-Side ESP
CWS	-	Canada-Wide Standards
U.S. DOE	-	United States Department of Energy
DC	-	Development Committee
DSI	-	Dry Sorbent Injection
dscm	-	dry standard cubic metre
EC	-	Environment Canada

ECO	-	Electro-Catalytic Oxidation
ENGO	-	Environmental Non-Government Organization
EPA	-	Environmental Protection Agency (United States)
EPG	-	Electric Power Generation (or Generating)
EPRI	-	Electric Power Research Institute
ESP	-	ElectroStatic Precipitator
FF	-	Fabric Filter
FGD	-	Flue Gas Desulphurization
FSW	-	Fuel Switching (to natural gas)
GC	-	Governing Council of the United Nations Environment Programme
GHGs	-	Greenhouse Gases
GLWQA	-	Great Lakes Water Quality Agreement
H_2O	-	water
HRSG	-	Heat Recovery Steam Generator
H_2SO_4	-	sulphuric acid
HAP	-	Hazardous Air Pollutant
HCl	-	hydrochloric acid
Hg	-	mercury
Hg^0	-	elemental or metallic mercury,
Hg_2^{1+}	-	mercurous ion (monovalent mercury)
Hg^{2+} or Hg^{++}	-	mercury II (mercuric ion, divalent mercury, oxidized/ionic form).
$HgCl_2$	-	Mercuric Chloride
HgO	-	Mercuric Oxide
HgS	-	Mercuric Sulphide
HS-ESP	-	Hot-Side ESP
ICR	-	Information Collection Request
IGCC	-	Integrated Gasification Combined Cycle
KCl	-	Potassium Chloride
kg	-	kilogram (1000 grams)
kWh	-	kilowatt-hour
lb	-	pound
L/G	-	Liquid to Gas ratio
LSD	-	Lime Spray Drying
LSFO	-	Limestone Forced Oxidation (wet scrubbing)
MACT	-	Maximum Achievable Control Technology
MAG	-	Multi-stakeholder Advisory Group
MBtu	-	Million British Thermal Units
MERS	-	Multi-Pollutant Emissions Reduction Strategy
MESA	-	MEcury Speciation Adsorption
mg	-	milligram (10^{-3} grams)
mmacf	-	million actual cubic feet

MW	-	Megawatt (million Watts)
MWe	-	Megawatt of electricity
MWh	-	Megawatt-hour
NAAQS	-	National Ambient Air Quality Standard
NAFTA	-	North American Free Trade Agreement
NARAP	-	North American Regional Action Plan
NAS	-	National Academy of Sciences (U.S.)
NEG/ECP	-	New England Governors / Eastern Canadian Premiers
NESCAUM	-	NorthEast States for Coordinated Air Use Management
NGO	-	Non-Government Organization
NHANES	-	National Health and Nutritional Survey
NH_3	-	Ammonia
NO	-	Nitric Oxide
NO_x	-	Nitrogen Oxides
NPRI	-	National Pollutant Release Inventory
NRC	-	National Research Council (U.S.)
OH	-	Ontario Hydro
OECD	-	Organization for Economic C0-Operation and Economic Development
OMB	-	Office of Mangement and Budget
PC	-	Pulverized Coal
pg	-	picogram (10^{-12} gram)
PJFF	-	Pulse-Jet Fabric Filter
PM	-	Particulate Matter
PM_{10}	-	Particulate Matter less than 10 microns in diameter
$PM_{2.5}$	-	Particulate Matter less than 2.5 microns in diameter
POP(s)	-	Persistent Organic Pollutant(s)
ppm	-	parts per million
PRB	-	Powder River Basin
RCRA	-	Resource Conservation and Recovery Act
RDIS	-	Residual Discharge Information System
RfD	-	Reference Dose (U.S.)
RTC	-	Report to Congress
S	-	sulphur
SC	-	spray cooling
scfm	-	standard cubic feet per minute
SCR	-	Selective Catalytic Reduction
SD	-	Spray Dryer
SDA	-	Spray Dry Absorber
SDS	-	Spray Dry Scrubbing
SNCR	-	Selective Non-Catalytic Reduction

SOP	-	Strategic Options Process
SOR	-	Strategic Options Report
SO_2	-	sulphur dioxide
SO_3	-	sulphur trioxide
TAC	-	Total Annualized Cost
TCC	-	Total Capital Costs
TCLP	-	Toxicity Characteristic Leaching Procedure
TDI	-	Tolerable Daily Intake (Health Canada)
TEQ	-	Toxic Equivalent
TRI	-	Toxics Release Inventory
TWG	-	Technical Working Group
UN ECE	-	United Nations Economic Commission for Europe
UNEP	-	United Nations Environment Programme
U.S. EPA	-	United States Environmental Protection Agency
WFGD	-	Wet FGD (also called LSFO)
WTE	-	Waste-To-Energy

GLOSSARY-PART B

DEFINTIONS OF TERMS

Ampere: The unit of measurement of electrical current produced in a circuit by 1 volt acting through a resistance of 1 ohm.

Ash: Impurities consisting of silica, iron, alumina, and other noncombustible matter that are contained in coal. Ash increases the weight of coal, adds to the cost of handling, and can affect its burning characteristics. Ash content is measured as a percent by weight of coal on a received or a dry (moisture-free, usually part of a laboratory analysis) basis.

Available but not Needed Capability: Net capability of main generating units that are operable but not considered necessary to carry load, and cannot be connected to load within 30 minutes.

Baseload: The minimum amount of electric power delivered or required over a given period of time at a steady rate.

Baseload Capacity: The generating equipment normally operated to serve loads on an around-the-clock basis.

Baseload Plant: A plant, usually housing high-efficiency steam-electric units, which is normally operated to take all or pan of the minimum load of a system, and which consequently produces electricity at an essentially constant rate and runs continuously. These units are operated to maximize system mechanical and thermal efficiency and minimize system operating costs.

Boiler: A device for generating steam for power, processing, or heating purposes or for producing hot water for heating purposes or hot water supply. Heat from an external combustion source is transmitted to a fluid contained within the tubes in the boiler shell. This fluid is delivered to an end-use at a desired pressure, temperature, and quality.

BTU (British Thermal Unit): A standard unit for measuring the quantity of heat energy equal to the quantity of heat required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

Capability: The maximum load that a generating unit, generating station, or other electrical apparatus can carry under specified conditions for a given period of time without exceeding approved limits of temperature and stress.

Capacity: The amount of electric power delivered or required for which a generator, turbine, transformer, transmission circuit, station, or system is rated by the manufacturer.

Capacity (Purchased): The amount of energy and capacity available for purchase from outside the system.

Capacity Charge: An element in a two-pad pricing method used in capacity transactions (energy charge is the other element). The capacity charge, sometimes called Demand Charge, is assessed on the amount of capacity being purchased.

Circuit: A conductor or a system of conductors through which electric current lows.

Coal: A readily combustible black or brownish-black rock whose composition, including inherent moisture, consists of more than 50 per cent by weight and more than 70 per cent by volume of carbonaceous material. It is formed from plant remains that have been compacted, hardened, chemically altered, and metamorphosed by heat and pressure over geologic time.

Cogeneration A generating facility that produces electricity and another form of useful thermal energy (such as heat or steam), used for industrial, commercial, heating, or cooling purposes.

Coincidental Demand: The sum of two or more demands that occur in the same time interval.

Coincidental Peak Load: The sum of two or more peakloads that occur in the same time interval.

Combined Cycle: An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. This process increases the efficiency of the electric generating unit.

Combined Cycle Unit: An electric generating unit that consists of one or more combustion turbines and one or more boilers with a portion of the required energy input to the boiler(s) provided by the exhaust gas of the combustion turbine(s).

Combined Cycle: An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. This process increases the efficiency of the electric generating unit.

Combined Cycle Unit: An electric generating unit that consists of one or more combustion turbines and one or more boilers with a portion of the required energy input to the boiler(s) provided by the exhaust gas of the combustion turbine(s).

Combined Pumped-Storage Plant: A pumped-storage hydroelectric power plant that uses both pumped water and natural stream-flow to produce electricity.

Commercial Operation: Commercial operation begins when control of the loading of the generator is turned over to the system dispatcher.

Consumption (Fuel): The amount of fuel used for gross generation, providing standby service, start-up and/or flame stabilization.

Contract Price: Price of fuels marketed on a contract basis covering a period of 1 or more years. Contract prices reflect market conditions at the time the contract was negotiated and therefore remain constant throughout the life of the contract or are adjusted through escalation clauses. Generally, contract prices do not fluctuate widely.

Contract Receipts: Purchases based on a negotiated agreement that generally covers a period of 1 or more years.

Cost: The amount paid to acquire resources, such as plant and equipment, fuel, or labor services.

Current (Electric): A flow of electrons in an electrical conductor. The strength or rate of movement of the electricity is measured in amperes.

Demand (Electric): The rate at which electric energy is delivered to or by a system, part of a system, or piece of equipment, at a given instant or averaged over any designated period of time.

Demand-Side Management: The planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand. It refers only to energy and load-shape modifying activities that are undertaken in response to utility-administered programs. It does not refer to energy and load-shape changes arising from the normal operation of the marketplace or from government-mandated energy-efficiency standards. Demand-Side Management (DSM) covers the complete range of load-shape objectives, including strategic conservation and load management, as well as strategic load growth.

Distribution System: The portion of an electric system that is dedicated to delivering electric energy to an end user.

Electric Plant (Physical): A facility containing prime movers, electric generators, and auxiliary equipment for converting mechanical, chemical, and/or fission energy into electric energy.

Electric Rate Schedule: A statement of the electric rate and the terms and conditions governing its application, including attendant contract terms and conditions that have been accepted by a regulatory body with appropriate oversite authority.

Electric Utility: A corporation, person, agency, authority, or other legal entity or instrumentality that owns and/or operates facilities for the generation, transmission, distribution, or sale of electric energy primarily for use by the public.

Energy: The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. Electrical energy is usually measured in kilowatthours, while heat energy is usually measured in British thermal units.

Energy Charge: That portion of the charge for electric service based upon the electric energy (kWh) consumed or billed.

Energy Deliveries: Energy generated by one electric utility system and delivered to another system through one or more transmission lines.

Energy Efficiency: Refers to programs that are aimed at reducing the energy used by specific end-use devices and systems, typically without affecting the services provided. These programs reduce overall electricity consumption (reported in megawatthours), often without explicit consideration for the timing of program-induced savings. Such savings are generally achieved by substituting technically more advanced equipment to produce the same level of end-use services (e.g. lighting, heating, motor drive) with less electricity. Examples include high-efficiency appliances, efficient lighting programs, high-efficiency heating, ventilating and air conditioning (HVAC) systems or control modifications, efficient building design, advanced electric motor drives, and heat recovery systems.

Energy Receipts: Energy generated by one electric utility system and received by another system through one or more transmission lines.

Energy Source: The primary source that provides the power that is converted to electricity through chemical, mechanical, or other means. Energy sources include coal, petroleum and petroleum products, gas, water, uranium, wind, sunlight, geothermal, and other sources.

Facility: An existing or planned location or site at which prime movers, electric generators, and/or equipment for convening mechanical, chemical, and/or nuclear energy into electric energy are situated, or will be situated. A facility may contain more than one generator of either the same or different prime mover type. For a cogenerator, the facility includes the industrial or commercial process.

Federal Energy Regulatory Commission (FERC): A quasi-independent regulatory agency within the Department of Energy having jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, oil pipeline rates, and gas pipeline certification.

FERC: The Federal Energy Regulatory Commission.

Firm Gas: Gas sold on a continuous and generally long-term contract.

Firm Power: Power or power-producing capacity intended to be available at all times during the period covered by a guaranteed commitment to deliver, even under adverse conditions.

Flue Gas Desulfurization Unit (Scrubber): Equipment used to remove sulfur oxides from the combustion gases of a boiler plant before discharge to the atmosphere. Chemicals, such as lime, are used as the scrubbing media.

Flue Gas Particulate Collectors: Equipment used to remove fly ash from the combustion gases of a boiler plant before discharge to the atmosphere. Particulate collectors include electrostatic precipitators, mechanical collectors (cyclones), fabric filters (baghouses), and wet scrubbers.

Fly Ash: Particulate matter from coal ash in which the particle diameter is less than 1 x 10 ^ -4 meter. This is removed from the flue gas using flue gas particulate collectors such as fabric filters and electrostatic precipitators.

Forced Outage: The shutdown of a generating unit, transmission line or other facility, for emergency reasons or a condition in which the generating equipment is unavailable for load due to unanticipated breakdown.

Fossil Fuel: Any naturally occurring organic fuel, such as petroleum, coal, and natural gas.

Fossil-Fuel Plant: A plant using coal, petroleum, or gas as its source of energy.

Fuel: Any substance that can be burned to produce heat; also, materials that can be fissioned in a chain reaction to produce heat.

Fuel Expenses: These costs include the fuel used in the production of steam or driving another prime mover for the generation of electricity. Other associated expenses include unloading the shipped fuel and all handling of the fuel up to the point where it enters the first bunker, hopper, bucket, tank, or holder in the boiler-house structure.

Full-Forced Outage: The net capability of main generating units that is unavailable for load for emergency reasons.

Gas: A fuel burned under boilers and by internal combustion engines for electric generation. These include natural, manufactured and waste gas.

Gas Turbine Plant: A plant in which the prime mover is a gas turbine. A gas turbine consists typically of an axial-flow air compressor, one or more combustion chambers, where liquid or gaseous fuel is burned and the hot gases are passed to the turbine and where the hot gases expand to drive the generator and are then used to run the compressor.

Generating Unit: Any combination of physically connected generator(s), reactor(s), boiler(s), combustion turbine(s), or other prime mover(s) operated together to produce electric power.

Generation (Electricity): The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in watthours (Wh).

Gross Generation: The total amount of electric energy produced by the generating units at a generating station or stations, measured at the generator terminals.

Net Generation: Gross generation less the electric energy consumed at the generating station for station use.

Generator: A machine that converts mechanical energy into electrical energy.

Generator Nameplate Capacity: The full-load continuous rating of a generator, prime mover, or other electric power production equipment under specific conditions as designated by the manufacturer. Installed generator nameplate rating is usually indicated on a nameplate physically attached to the generator.

Geothermal Plant: A plant in which the prime mover is a steam turbine. The turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The energy is extracted by drilling and/or pumping.

Gigawatt (GW): One billion watts.

Gigawatthour (GWh): One billion watthours.

Greenhouse Effect: The increasing mean global surface temperature of the earth caused by gases in the atmosphere (including carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbon). The greenhouse effect allows solar radiation to penetrate but absorbs the infrared radiation returning to space.

Grid: The layout of an electrical distribution system.

Gross Generation: The total amount of electric energy produced by a generating facility, as measured at the generator terminals.

Hydroelectric Plant: A plant in which the turbine generators are driven by failing water.

Industrial: The industrial sector is generally defined as manufacturing, construction, mining agriculture, fishing and forestry establishments Standard Industrial Classification (SIC) codes 01-39. The utility may classify industrial service using the SIC codes, or based on demand or annual usage exceeding some specified limit. The limit may be set by the utility based on the rate schedule of the utility.

Intermediate Load (Electric System): The range from base load to a point between base load and peak. This point may be the midpoint, a per cent of the peakload, or the load over a specified time period.

Internal Combustion Plant: A plant in which the prime mover is an internal combustion engine. An internal combustion engine has one or more cylinders in which the process of combustion takes place, converting energy released from the rapid burning of a fuel-air mixture into mechanical energy. Diesel or gas-fired engines are the principal types used in electric plants. The plant is usually operated during periods of high demand for electricity.

Interruptible Gas: Gas sold to customers with a provision that permits curtailment or cessation of service at the discretion of the distributing company under certain circumstances, as specified in the service contract.

Interruptible Load: Refers to program activities that, in accordance with contractual arrangements, can interrupt consumer load at times of seasonal peak load by direct control of the utility system operator or by action of the consumer at the direct request of the system operator. It usually involves commercial and industrial consumers. In some instances the load reduction may be affected by direct action of the system operator (remote tripping) after notice to the consumer In accordance with contractual provisions. For example, loads that can be interrupted to fulfill planning or operation reserve requirements should be reported as Interruptible Load. Interruptible load as defined here excludes Direct Load Control and Other Load Management. (Interruptible Load, as reported here, is synonymous with Interruptible Demand reported to the North American Electric Reliability Council on the voluntary Office of Energy Emergency Operations Form OE-411, 'Coordinated Regional Bulk Power Supply Program Report," with the exception that annual peakload effects are reported on the Form EIA-861 and seasonal (i.e., summer and winter) peakload effects are reported on the OE-41 1).

Kilowatt (kW): One thousand watts.

Kilowatthour (kWh): One thousand watthours.

Load (Electric): The amount of electric power delivered or required at any specific point or points on a system. The requirement originates at the energy-consuming equipment of the consumers.

Maximum Demand: The greatest of all demands of the load that has occurred within a specified period of time.

Mcf: One thousand cubic feet.

Megawatt (MW): One million watts.

Megawatthour (MWh): One million watthours.

MMcf: One million cubic feet.

Natural Gas: A naturally occurring mixture of hydrocarbon and nonhydrocarbon gases found in porous geological formations beneath the earth's surface, often in association with petroleum. The principal constituent is methane.

Net Capability: The maximum load-carrying ability of the equipment, exclusive of station use, under specified conditions for a given time interval, independent of the characteristics of the load. (Capability is determined by design characteristics, physical conditions, adequacy of prime mover, energy supply, and operating limitations such as cooling and circulating water supply and temperature, headwater and tailwater elevations, and electrical use.)

Net Generation: Gross generation minus plant use from all electric utility owned plants. The energy required for pumping at a pumped-storage plant is regarded as plant use and must be deducted from the gross generation.

Net Summer Capability: The steady hourly output, which generating equipment is expected to supply to system load exclusive of auxiliary power, as demonstrated by tests at the time of summer peak demand.

Net Winter Capability: The steady hourly output which generating equipment is expected to supply to system load exclusive of auxiliary power, as demonstrated by tests at the time of winter peak demand.

Noncoincidental Peak Load: The sum of two or more peakloads on individual systems that do not occur in the same time interval. Meaningful only when considering loads within a limited period of time, such as a day, week, month, a heating or cooling season, and usually for not more than 1 year.

Non-Firm Power: Power or power-producing capacity supplied or available under a commitment having limited or no assured availability.

Nonutillity Power Producer: A corporation, person, agency, authority, or other legal entity or instrumentality that owns electric generating capacity and is not an electric utility. Nonutility power producers include qualifying cogenerators, qualifying small power producers, and other nonutility generators (including independent power producers) without a designated franchised service area.

Nuclear Fuel: Fissionable materials that have been enriched to such a composition that, when placed in a nuclear reactor, will support a self-sustaining fission chain reaction, producing heat in a controlled manner for process use.

Nuclear Power Plant: A facility in which heat produced in a reactor by the fissioning of nuclear fuel is used to drive a steam turbine.

Off-Peak Gas: Gas that is to be delivered and taken on demand when demand is not at its peak.

Ohm: The unit of measurement of electrical resistance. The resistance of a circuit in which a potential difference of 1 volt produces a current of 1 ampere.

Outage: The period during which a generating unit, transmission line, or other facility is out of service.

Peak Demand: The maximum load during a specified period of time.

Peak Load Plant: A plant usually housing old, low-efficiency steam units; gas turbines; diesels; or pumped-storage hydroelectric equipment normally used during the peak-load periods.

Peaking Capacity: Capacity of generating equipment normally reserved for operation during the hours of highest daily, weekly, or seasonal loads. Some generating equipment may be operated at certain times as peaking capacity and at other times to serve loads on an around-the-clock basis.

Per cent Difference: The relative change in a quantity over a specified time period. It is calculated as follows: the current value has the previous value subtracted from it; this new number is divided by the absolute value of the previous value; then this new number is multiplied by 100.

Planned Generator: A proposal by a company to install electric generating equipment at an existing or planned facility or site. The proposal is based on the owner having obtained (1) all environmental and regulatory approvals, (2) a signed contract for the electric energy, or (3) financial closure for the facility.

Plant: A facility at which are located prime movers, electric generators, and auxiliary equipment for converting mechanical, chemical, and/or nuclear energy into electric energy. A plant may contain more than one type of prime mover.

Plant Use: The electric energy used in the operation of a plant. Included in this definition is the energy required for pumping at pumped-storage plants.

Plant-Use Electricity: The electric energy used in the operation of a plant. This energy total is subtracted from the gross energy production of the plant; for reporting purposes the plant energy production is then reported as a net figure. The energy requited for pumping at pumped-storage plants is, by definition, subtracted, and the energy production for these plants is then reported as a net figure.

Power: The rate at which energy is transferred. Electrical energy is usually measured in watts. Also used for a measurement of capacity.

Power Pool: An association of two or more interconnected electric systems having an agreement to coordinate operations and planning for improved reliability and efficiencies.

Prime Mover: The engine, turbine, water wheel, or similar machine that drives an electric generator; or, for reporting purposes, a device that converts energy to electricity directly (e.g., photovoltaic solar and fuel cell(s)).

Profit: The income remaining after all business expenses are paid.

Pumped-Storage Hydroelectric Plant: A plant that usually generates electric energy during peak-load periods by using water previously pumped into an elevated storage reservoir during off-peak periods when excess generating capacity is available to do so. When additional generating capacity is needed, the water can be released from the reservoir through a conduit to turbine generators located in a power plant at a lower level.

Purchased Power Adjustment: A clause in a rate schedule that provides for adjustments to the bill when energy from another electric system is acquired and it varies from a specified unit base amount.

Pure Pumped-Storage Hydroelectric Plant: A plant that produces power only from water that has previously been pumped to an upper reservoir.

Rate Base: The value of property upon which a utility is permitted to earn a specified rate of return as established by a regulatory authority. The rate base generally represents the value of property used by the utility in providing service and may be calculated by any one or a combination of the following accounting methods: fair value, prudent investment, reproduction cost, or original cost. Depending on which method is used, the rate base includes cash, working capital, materials and supplies, and deductions for accumulated provisions for depreciation, contributions in aid of construction, customer advances for construction, accumulated deferred income taxes, and accumulated deferred investment tax credits.

Receipts: Purchases of fuel.

Regulation: The governmental function of controlling or directing economic entities through the process of rulemaking and adjudication.

Reserve Margin (Operating): The amount of unused available capability of an electric power system at peakload for a utility system as a percentage of total capability.

Retail: Sales covering electrical energy supplied for residential, commercial, and industrial end-use purposes. Other small classes, such as agriculture and street lighting, also are included in this category.

Running and Quick-Start Capability: The net capability of generating units that carry load or have quick-start capability. In general, quick-start capability refers to generating units that can be available for load within a 30-minute period.

Sales: The amount of kilowatthours sold in a given period of time; usually grouped by classes of service, such as residential, commercial, industrial, and other. Other sales include public street and highway lighting, other sales to public authorities and railways, and interdepartmental sales.

Sales for Resale: Energy supplied to other electric utilities, cooperatives, municipalities, and Federal and State electric agencies for resale to ultimate consumers.

Scheduled Outage: The shutdown of a generating unit, transmission line, or other facility, for inspection or maintenance, in accordance with an advance schedule.

Short Ton: A unit of weight equal to 2,000 pounds.

Small Power Producer (SPP): A small power production facility (or small power producer) generates electricity using waste, renewable (water, wind and solar), or geothermal energy as a primary energy source. Fossil fuels can be used, but renewable resource must provide at least 75 per cent of the total energy input.

Spinning Reserve: That reserve generating capacity running at a zero load and synchronized to the electric system.

Spot Purchases: A single shipment of fuel or volumes of fuel, purchased for delivery within 1 year. Spot purchases are often made by a user to fulfill a certain portion of energy requirements, to meet unanticipated energy needs, or to take advantage of low-fuel prices.

Stability: The property of a system or element by virtue of which its output will ultimately attain a steady state. The amount of power that can be transferred from one machine to another following a disturbance. The stability of a power system is its ability to develop restoring forces equal to or greater than the disturbing forces so as to maintain a state of equilibrium.

Standby Facility: A facility that supports a utility system and is generally running under no-load. It is available to replace or supplement a facility normally in service.

Standby Service: Support service that is available, as needed, to supplement a consumer, a utility system, or to another utility if a schedule or an agreement authorizes the transaction. The service is not regularly used.

Steam-Electric Plant (Conventional): A plant in which the prime mover is a steam turbine. The steam used to drive the turbine is produced in a boiler where fossil fuels are burned.

Stocks: A supply of fuel accumulated for future use. This includes coal and fuel oil stocks at the plant site, in coal cars, tanks, or barges at the plant site, or at separate storage sites.

Substation: Facility equipment that switches, changes, or regulates electric voltage.

Sulfur: One of the elements present in varying quantities in coal which contributes to environmental degradation when coal is burned. In terms of sulfur content by weight, coal is generally classified as low (less than or equal to 1 per cent), medium (greater than 1 per cent and less than or equal to 3 per cent), and high (greater than 3 per cent). Sulfur content is measured as a per cent by weight of coal on an 'as received' or a 'dry' (moisture-free, usually part of a laboratory analysis) basis.

Switching Station: Facility equipment used to tie together two or more electric circuits through switches. The switches are selectively arranged to permit a circuit to be disconnected, or to change the electric connection between the circuits.

System (Electric): Physically connected generation, transmission, and distribution facilities operated as an integrated unit under one central management, or operating supervision.

Transformer: An electrical device for changing the voltage of alternating current.

Transmission: The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers, or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer.

Transmission System (Electric): An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or is delivered to other electric systems.

Turbine: A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

Useful Thermal Output: The thermal energy made available for use in any industrial or commercial process, or used in any heating or cooling application, i.e., total thermal energy made available for processes and applications other than electrical generation.

Voltage Reduction: Any intentional reduction of system voltage by 3 per cent or greater for reasons of maintaining the continuity of service of the bulk electric power supply system.

Watt: The electrical unit of power. The rate of energy transfer equivalent to 1 ampere flowing under a pressure of 1 volt at unity power factor.

Watthour (Wh): An electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

Wheeling Service: The movement of electricity from one system to another over transmission facilities of intervening systems. Wheeling service contracts can be established between two or more systems.

Wholesale Sales: Energy supplied to other electric utilities, cooperatives, municipals, and Federal and State electric agencies for resale to ultimate consumers.

(Power Market Association) http://www.intr.net.pma

Appendix A Mercury Stories

A.1 Mercury - My Story

This is a story on how my involvement in mercury began and where it has taken me from a very personal perspective. I call it “My Story”.

For the past few years, I have become engulfed, entrenched, immersed and strangely fascinated and horrified by mercury. Whatever information I have uncovered or discovered about mercury, it is never enough and I search for more. This “addiction” started when I got involved, by my own doing I might add, in a Canada-wide process to set standards for mercury emissions. In a typically fragmented way in which Canadian governments tend to perceive the environment, they embarked on a standards-setting exercise for a limited number of priority substances of concern to human health and the environment and had deemed mercury as one such priority substance.

During a telephone conversation in December, 1999 that would firm up my involvement as a “stakeholder” in the Canada-wide Standards process for mercury, I was offered a choice – what mercury-emitting sector do you want to be involved in - smelters, incinerators, or electric-power generators? Choices like these come all too rarely in life. Being the sacrificial environmentalist that I am, I asked where I might be of most value. If the person on the other line knew me at all, the answer would be in an area where the corporate status quo could be challenged. If they didn’t know me, I would serve as a slot in the category of a representative from environmental organizations to fulfil the requirements for stakeholder representation. The choice became the electric power sector – a rather discrete non-descriptive category primarily referring to coal-fired plants.

Knowing full well the limitations of stakeholder participation as a volunteer, I engaged in this exercise at first with caution. That didn’t last long. I had some knowledge about mercury, that it was a heavy metal, indestructible and extremely toxic. I remembered playing with runaway balls of mercury in physics labs. I was well aware of its effects on fish and wildlife. And as a family of “fishers” who generally ate what they caught, was keenly aware of fish advisories. I knew about Minamata Disease, or methylmercury poisoning in Japan. And now I was about to learn more, much more, about mercury, coal-fired plants and an intransigent industry.

At first, the process was so utterly flawed that I questioned my continuance, a common sentiment felt by environmentalists in “participating” in such consultation exercises. While you are invited as a guest to the table, your mere presence is taken to sanctify the process. In reality, when the time for making decisions arrives, you are summarily dismissed from the table. You have a choice - either go along with the window-dressing and get sucked into the vortex of consultation and leave with minimum impact OR pull open the blinds with all your might and rattle the patriarchy as hard as you can. I went for the latter. Other than knowing that I needed to understand more, gain more insight, be creative, I was just beginning to delve into mercury and power plants with a passion that would know no bounds.

The more I inquired, read, and was told, the more I had to know – from the very technical aspect of boilers and scrubbers to the cultural and mythical. It's rather encouraging that after all these years, I still thirst for such knowledge, but then knowledge gives power, and I needed all the power I could muster to engage with the people from the power industry. Everywhere I went I would talk about mercury. Sensing my urgency, people usually had a story to tell about their personal awareness of mercury. Gradually, I was collecting more and more stories and in turn, I would spread them around, like "a mercury hot-line", and more stories would surface. Mercury was becoming my mantra. My friends thought that I was overly obsessed and obsessing. Was I filling a deep void in my life – was it really as bad as I said? I was beginning to lose dinner invitations and questioning my own sanity and well-being. Mercury, a trickster and trader, elusive and volatile, the messenger of the gods, was becoming my tormenter, as I in turn was becoming its messenger.

In the meantime, I continued to participate in the Canada-wide Standards consultation process with the electric power sector, but with increasing frustration and impatience. If anything was materializing from the numerous teleconference calls and workshops, it was the solidification of positions or perhaps more appropriately, lack thereof. The consistent inflexibility and reticence of industry was matched by the reluctance of government representatives to demonstrate the fortitude needed to move the discussions to a higher plane, so to speak. The CWS process was floundering like a ship cast adrift with no captain, no navigator, not even a map or a destination. How could this process ever be expected to accomplish its mission and set a standard that would result in reduction of mercury emissions from coal-fired plants?

Despite my misgivings and better judgement, I resolved to stay in the fray and play my cards the way I best know how. I have no illusions about my role in this process. It would continue to be isolating, demanding and emotionally charged and I would be portrayed as a troublemaking irritant and agitator. But what other avenues are there in Canada that would focus on mercury reductions specifically from coal-fired plants? For so many reasons, it was timely and necessary am not one to give up, nor am I easily dismissed, and with all things considered, "*to thine ownself be true*".

As I poured over numerous articles on mercury and more particularly methylmercury poisoning in Iraq, Guatemala, Brazil, Mexico, Japan and in Canada, I became increasingly incensed over the damage that was inflicted on the affected communities, and in particular, on the children, pregnant women, the unborn, the fish and wildlife. So little of this is publicly known in Canada. Once more, it is the so-called sensitive populations with no voice or power who suffer the most who are easily forgotten. I wanted to reveal the injustices that have been done in the past and continue to be done now and I wanted to bring all of this closer to home.

With ***MERCURY*** as the catalyst, I would set out to ignite public indignation. I would defrock the corporate emperors who in their frenzied pursuit of power and profit continue to spew out their self-serving profit-maximizing creed unabated along with toxic chemicals whilst governments render themselves powerless in compliance. How can I slay the dragon? What can a lone messenger do?

So I started a campaign – I wanted to tell everyone about mercury and the dirty coal-fired plants. I drew up a Position Paper that said YES to setting standards and NO to buckling in to the industry agenda of denial and business as usual. I asked groups around the country to sign on and endorse the position paper – and so many did, more than 100 health, environment, labour, public interest groups and First Nations. The message was seeping out – but more needed to happen to make any impact.

When the Chief of the Deninu Kue Nation and the Inuit in the North West Territories wrote to me endorsing the position paper, I realized just how strong my emotional intensity and personal commitment to this issue was. No other endorsements could mean as much or affect me to the same degree. It is often their way of life, their food source that is so threatened by contamination from mercury and other hazardous chemicals that originate from exploitation and industries very far away.
……

Back to the home front and the Oak Ridges Moraine – the hottest political environmental issue in Southern Ontario, hitting the press almost on a daily basis. Over a beer in Stouffville, talking about anything and everything, a friend of mine talked about wanting to write a story about a woman who is so taken up, so passionate about mercury and why she is so. That's me! The subject and object have become inseparable. Before I would be able to write more about mercury – I needed to reflect on my own commitment and write my own story.

I first met Peter and his wife Sandy, residents of Preston Lake, a "kettle lake" on the Oak Ridges Moraine, at a STORM meeting in a cold church basement in November 2000. They were talking about the particular problems that they were encountering at Preston Lake, the development pressures, eutrophication of the lake, pesticide use, the split within the community and the residents, potential lawsuits, and the lake…. always going back to the lake. The details of their battles were vivid, but there was something more, something that resonated so strongly with me. The details faded from my conscience as I was drawn to Peter's passion, his connection and attachment to the lake, and how the struggles that he was engaged in were affecting every aspect of his life. His compassion and commitment were sincere – and he was not about to let go. Preston Lake and what it signified to him were to be passed on to his daughter.

Peter talked about the fish in Preston lake, a very small body of water, perhaps 35 acres in all on the height of the Moraine, only about 25 kilometers from Toronto. He told us about the huge largemouth bass of over 10 pounds that was caught in the lake over 20 years ago mounted in his "fish-house" at the lake. To this day that fish remains the record for largemouth bass in Ontario.

The uneasy parallel of our struggles along with our trials and tribulations began to take on a greater depth and meaning. As Peter talked, my mind drifted to a newspaper article that I had come across in researching mercury in trying to get some perspective of the amount of damage that mercury could inflict.

"It takes only 1/70th of a teaspoon, or one gram, of mercury to contaminate a 25 acre lake to the point where the fish are unsafe to eat." Here, in this church basement was a picture

of a very large, even oversized fish, caught on a small lake in the vicinity of my home. In all my research and writings on mercury, I have been searching for a way to bring this issue to a scale that people could relate to, and here it was, in front of me.

That very same day, my curiosity getting the better of me, I headed off to Preston Lake to visit with Peter and Sandy and catch a glimpse of the mounted fish and the lake. Taking k my own time , I stood alone at the shore, still and cautious, focusing on the lake as if I wanted to retain a mental image of it for a long time. Looking upward, I traced the path of the 1/70th of a teaspoon of mercury from its possible origin, the coal plants on the shore of Lake Ontario to Preston Lake.

The mercury fell with the rain, some settling onto the branches of the trees and the leaves, most splashing playfully onto the surface of the placid lake. But the enticing game suddenly ceased as the mercury penetrated the surface, gravitating to the bottom, all the while being magically transformed by microbial action into its most dangerous form, methylmercury. The little fish and insects that feed on the microbial life would now fill their gills with methylmercury. In turn, the larger fish, the predators, would feed on the little fish and become infused with methylmercury in their tissue, for the larger the fish, the higher the concentration of methylmercury. That is the strength and potency of this trickster compound, methylmercury, and its "natural and particular" property to bioaccumulate by millions through the food chain. Those fish were now contaminated, poisoned with mercury. Whoever eats the fish here in Preston Lake or in any other body of water contaminated with mercury, be it humans, loons, otters, belugas and seals, will ingest methylmercury which in turn will penetrate through to the very essence of life – the fetuses, the offspring, the females of all species. And methylmercury, ever persistent that it is, does not let go.

After my brief reverie on the shores of Preston Lake, I joined Peter at his fish house to see the mounting of the "trophy" fish. Peter pointed to a poster on the wall - The Homeless in Toronto – and proudly told me that it was his photograph that was in the poster. As I was about to leave from this very brief visit, he gave me a poster of a young Cree woman standing on a rock and at the base was written the Cree prophecy…

Only after the last tree has been cut down,
Only after the last river has been poisoned,
Only after the last fish has been caught,
Only then will you find that money cannot be eaten.

Later that evening another story began to unfold. It was about my family and a lake that we cherish. It was to become my story that would carry me through some very turbulent times through the next few years. And just as Peter's line was drawn in the sand – so was mine.

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It was a beautiful early evening on the lake, Percy Lake, calm and inviting, and fishing time, and a scene that was so typical of that period in my life. The boat was loaded with all the gear and drinks. My 8-year-old daughter Elinor was slicing worms, and then casting, with the relish, freedom and joy of a child in her element. Her dad, her closest fishing

buddy, guided the boat as it made its way to the mouth of the river, fishing and trawling all the while. I was there for the ride, a book in hand, glancing from time to time at the lake, knowing that the peaceful moment would not last. *Mick, my son, was not in the boat, and typical of "the older brother", preferred to fish off the dock.*

Then, excitement! Elinor feels a strong tug at her line, the rod arches over with the weight of a fish – the dog is jumping up and down, lines are getting tangled, chaos - she's reeling it in, she's got it – the largest smallmouth bass she has ever caught! She asks me if we could eat it for supper. *What could surpass eating a fresh catch from one so innocent and young? Elinor was not a believer in catch for catch sake – it seemed so cruel to her.* We would beach the boat by the rock, make a fire, Elinor would gut and clean the fish and maybe I would cook it over the open fire – it would be just great!

We look at each other, her dad and I, without a word, aware that not all the fish may be safe to eat. (*Is the fish consumption guidebook handy in the boat? Likely not!.)* After all, it is children and pregnant women who are particularly sensitive to mercury-contaminated fish. Is this fish safe to eat? The fish is still alive and we need to decide fast. What do we do?

I have to take the responsibility – I have to be the one to tell her.

"Elinor, we're not sure if this fish is safe, fish can be full of a lot of poisons, with something called mercury. It's too bad but you can't simply eat everything you catch anymore. We have to check to be sure, particularly for you and me. We can't take a chance."

"But mommy, don't the loons and ducks in the lake eat the fish? How can they check if the fish are safe? Won't they be poisoned?"

And I tell her the truth… "Yes, it's possible."
"What will happen to me if I eat a poisoned fish? Do I get sick right away?"

"Maybe not right away, but if you eat too much fish, it could be a problem."
Elinor was intent – frowning, pouting, disappointing and angry at the same time. No fire, no fun, no guts. But she wasn't quite ready to give up. "Where does this. …mercury come from anyway, how does it get into Percy Lake, and into the fish?"

How do you begin to answer a child who must know – who bears the consequence of the acts of others? She deserves an explanation, that is the very least we can do.

Reluctantly, we throw the fish, still alive, jumping in the boat, back into the lake.

……..

As I picture my daughter at 8 years old, I recall catching my first fish at about the same age, and my mother cleaning and preparing as part of our supper. We did not question whether the fish might be full of toxic substances or whether it was safe to eat. Whoever

dreamt of the need for fishing guides? After all, wasn't Canada supposed to be the vast landwhere you could drink the water from the lakes, swim in the rivers, and eat fish?

I can recall another earlier family scene a number of years ago, on our way to Manitoulin Island – all four of us. We were at a campsite in Johnny Lake, near Killarney Provincial Park, south-west of Sudbury. Such a pretty lake, what a discovery, must be great for fishing.

So once more, we launch the boat, toss in the fishing gear – we're bound to catch something here. The lake was narrow, quiet and almost ghostly, along the shoreline rimmed with steep granite rocks. After several hours had gone by, still no fish had been caught – nor were there any nibbles on the lines. As we headed back to the campsite, the people standing at the dock looked at us with all the fishing gear somewhat bemused, laughing in a mocking way - city slickers, not knowing very much about this lake, did we? No luck, we say, somewhat surprised. "Of course not" was the chorus from the dock. "Johnny Lake's been dead for years now. Acid Rain. That's what has happened to all the lakes around here. It's coming from the stacks in Sudbury. The fishing is over. Look at the trees – the tops of the maples – not like they used to be."

Today, as I picture Johnny Lake, its stillness and beauty, I laugh at my own ignorance – and feel a little ashamed. Despite the movement that brought Acid Rain to the forefront of media coverage to the point where governments were forced to act, here we are today, still mired with the effects of acid rain. Strange beings we are that with all that we know and all that has been ruined over the years, there are those who find it okay to fish in Johnny Lake and catch nothing.

A2. Coal in our Environment – The Story of Coal

Coal is a complex substance, whose very essence lies in its formation and evolvement over eons of time. It is a fossil fuel, that is, material derived from the decomposition of living matter over millions of years. Rich in carbon and hydrogen, fossil fuels release energy in the form of heat when burned or combusted. This heat is subsequently used to produce power and drive other processes. The composition and abundance of coal have made it a very popular source of electricity in the world.

Digging deeper into words and their meanings requires reference to the ever-so-handy and valuable resource, Webster's Dictionary. Accordingly, **fossil** is a remnant, trace or impression of an animal or plant of past geological ages that has been preserved in the earth's crust, or material such as coal, oil, gas derived from living matter. It is also defined as one whose views are outmoded, or something rigidly fixed. The same venerable source defines **coal** as a black or brownish black solid combustible substance formed by the partial decomposition of vegetative matter without access to air and under the influence of moisture, increased pressure and temperature.

An "alternative" definition of coal is a cheap source of energy and heat that profits corporate fossils, but whose true cost is beyond our reach, an ever-diminishing return.

Coal is formed from vegetation such as trees, ferns and other plants that lived 300 to 400 million years ago. Buried deeply under the heavy weight of hundreds and thousands of meters of earth, rock and ancient seas, with the passage of time, the vegetation slowly rotted into organic materials that formed vast deposits of matter, namely coal [75].

As a potter slowly and methodically manipulates and molds the soft clay, transforming, and refining its shape, natural forces of pressure and temperature squeeze moisture and gases from the newly-formed coal, molding and transforming it gradually over eons from a soft moist brown substance to a harder, more dense material.

As the coal ages and morphs over time, its characteristics are altered. The various stages of transition are typically divided into four categories to reflect not only age, but also depth and traits such as hardness and dryness, carbon content, volatile matter and heating value. **Lignite**, the youngest of coal, is soft, brown to black with visible original plant material. **Subbituminous** coal is banded and black but still soft, with traces of woody layers. **Bituminous** coal, the most common of coals, is black and hard. Anthracite, the oldest and deepest buried, is a glassy textured dense carbon-rich rock. Of all types of coal, anthracite has the lowest sulphur content and the highest heating value. It is also the most rare and the most costly to mine.

[75] Other fossil fuels, namely oil and gas, were formed from tiny organisms that settled to the bottom of ancient seas and rivers. Under the influence of temperature and pressure, these organisms decayed over time forming oil or gas, the latter being favoured by hotter temperatures and greater pressures.

Coal-fired Plants

The prevalence of coal as a source of fuel lies in the shear vastness of coal deposits worldwide, making coal a relatively cheap, accessible source of fuel. In many parts of the world, coal-fired plants are the primary source of electricity production, irrespective of the relatively low efficiency of electricity generation from fossil fuels[76]. As much as 23 percent of Canada's total electrical energy are supplied by fossil fuels, with coal providing the lion's share at 18 percent [77]. In the United States, over half of the electric power generation is dominated by fossil fuels, primarily coal[78].

The "usefulness" of fossil fuels in the generation of energy lies in their inherent source of chemical energy, primarily from their carbon and hydrogen content, that is converted to heat energy when the fuels are burned. However, coal and oil contain more than carbon and hydrogen. They also contain varying amounts of sulphur and nitrogen as well as numerous trace elements such as heavy metals and minerals that were trapped underground during the formation of fossil fuels. Many of the trace elements are toxic substances and are released when fossil fuels are burned at high temperatures.

The degree and nature of substances that are emitted from the combustion of coal depend on many factors – the properties and type of coal, the generating and operational capacity of the plant, the state of the equipment, firing conditions and the control technologies employed. But of this there is no doubt - the combustion of coal causes emissions of particles and gases into the atmosphere that are harmful to human health and the environment.

Coal-fired Electric Power Plants: A Simplified Primer
A Tale of Two Processes

In generating electricity from coal, two processes are played out simultaneously in a thermal power plant; one enables the other, each a function of the other. In one process, chemical energy bound in coal is unleashed and in conformity with the laws of thermodynamics, converted to other forms of energy, eventually leading to the generation of electricity. This process begins with the injecting coal into a boiler [79], where it is combusted at high temperatures, transforming its chemical energy into heat energy. The heat energy is transmitted to water that is contained in tubes in the boiler and converts the water into high-pressure steam. The steam passes through a turbine where it expands to a lower pressure, releasing energy that spins the shaft of the turbine at a very high speed. The resulting mechanical energy is finally used to rotate the armature of an electric generator, thereby producing electrical energy.

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[76] The overall efficiency of electricity generation from fossil fuels (ratio of net energy output to total energy input) is about 30-35 percent according to the 1997 Industry Annual Report of the Canadian Electric Association, pp. 9-11

[77] Canadian Electrical Association – Electric Power in Canada, 1997 p. iv; Ontario Ministry of the Environment "Coal-Fired Electricity Generation in Ontario", March 2001

[78] The Clean Energy Group Air Toxics Emissions from Electric Power Plants, June 1999; 1997 data. P.8

[79] A boiler is a device for generating steam – like a kettle.

While the energy cycle is progressing, another somewhat more sinister process is occurring in the boiler. This process is initiated by the combustion of coal that drives the first. In this case though, the focus is on coal itself and the transformations and chemical reactions that take place in the aftermath of combustion – in the boiler and beyond.

Many gases as well as numerous substances known to be hazardous air pollutants are formed both during and after combustion. Trace elements that were locked up in the coal are set free. The litany of substances - sulphur dioxide, nitrogen oxides, carbon dioxide, arsenic, cadmium, lead, mercury, benzene, dioxins and furans, and acid gases are just a few examples of the plethora of pollutants released or formed as a result of combustion.

The combustion of coal is not necessarily complete - in other words, not all the coal is burned. The residue of ash and remnants of unburned coal contain not only some of the original trace elements of coal but gases and acids. The larger ash particles, bottom ash, tend to settle at the bottom of the boiler and are removed for disposal in landfill. The finer ash, known as fly ash or particulate matter is carried along with the combustion gases in the flue to air pollution control devices such as electrostatic precipitators designed to remove some of the pollutants [80].

While air pollution control devices may capture some of the particles, the effectiveness of the control technology is limited. Most of the fly ash that is captured by these devices ends up in landfill, while a small fraction may be marketed and utilized in by-products, such as in the production of concrete and cement and to a lesser extent in steel manufacturing as a hardening agent[81]. The fly ash that does escape control is generally smaller in size and is emitted from the plant stack into the atmosphere in the form of gases or and particle matter.

Along with the finer fly ash, gases and acidic aerosols as well as numerous other elements and substances are emitted into the atmosphere. These various substances are toxic and some are carcinogenic. In the atmosphere, chemical reactions flourish as other dangerous pollutants are formed. As the toxic plume of smoke curls away from the plant stack, penetrating through the air, the pollutants are dispersed, drifting and depositing both near and far from its source, even thousands of kilometers. In altered states, the coal of the past, now a plume of smoke can not disappear. There is no “away”.

[80] Fly ash is fine residue known as particulate matter less than $1x10^{-4}$ meters in diameter, that is removed from the flue gas by particulate collectors such as fabric filters and electrostatic precipitators. Fly ash results from the combustion of pulverized coal commonly used in many generating plants.

[81] According to Industry Annual Report of the Canadian Electricity Association (CEA), 1997, approximately 18% of residue were redirected for use. On a utility-specific basis, utilization ranged from a low of 0% to 56%.

The Toll from Coal – In Brief

Coal-fired generating plants are a major source of miniscule particles that lead to respiratory problems and premature mortality. Their emissions are the primary components of acid rain and smog and a major contributing factor to climate change [82]. They emit numerous hazardous pollutants, some of which are neurotoxic and fetotoxic capable of persisting in the environment for decades. Furthermore, they contribute to the diminishing capacity of a number of water bodies to sustain the qualities with which they are attributed. Reduced reproduction levels, neurological deficiencies and other effects observed in birds and mammals can be linked to the toxic pollutants emitted in the air that are deposited on land and in water, where some of the pollutants accumulate up the food chain. Increased emissions from power plants due to restructuring could exacerbate these environmental problems.

The extent of the cumulative impact and the heavy burden that such facilities exert on the quality of air, land, and water and on human health and wildlife may not be easily quantified, but the damage that is witnessed today could be only the tip of the iceberg. With all things considered, the inordinate reliance on fossil fuels as an energy source is misguided and indeed troublesome as it continues and flourishes into the 21st century.

Coal-fired Plants and Mercury

The increasing levels of mercury in the environment are placing exposed individuals and wildlife at heightened risk. Of primary concern is the transport and eventual deposition of airborne mercury, its transformation into methylmercury, a highly toxic form that bioaccumulates in the aquatic food chain, and its persistence in the environment.

The focus placed on coal-fired plants stems from their significant and increasing role as a major contributor to anthropogenic mercury, particularly in the absence of stringent and binding commitments.

Mercury has reached levels that are placing exposed individuals and wildlife at risk. Of primary concern is the transport and eventual deposition of airborne mercury, its transformation into a highly toxic form, methylmercury that bioaccumulates in the aquatic food chain, and its persistence in the environment.

Fossil fuels, primarily coal and oil contain trace amounts of mercury. Coal, the fossil fuel most utilized in Canada for generation of electricity, contains the highest amount of mercury. Upon combustion, mercury is released from coal. The elevated high temperatures in the boiler and the volatility of mercury lead to mercury vaporizing and being emitted from the combustion area as a gas. Virtually no mercury is found in the bottom ash. As the combustion gases pass through the boiler and the air pollution control system, they cool, and small amounts of compounds containing mercury may adsorb on the surface of fine

[82] In Canada, about 15% of total GHG emissions result from these facilities.

particles. Most likely, mercury will remain in a gaseous phase, as a vapour, and pass through gas cleaning devices to be emitted into the atmosphere [83].

The amount of mercury emitted by these plants depends on many factors, such as the amount and type of coal, the specific coal seam, mercury content and heating value and the effective emission controls [84]. Nonetheless since mercury is an element and indestructible, ***the amount of mercury in coal prior to combustion should equate with the amount of mercury released into the environment after combustion – whether it is in air, deposited in landfill or incorporated in some way***.

What we do know is that mercury is a neurotoxin and fetotoxin. We know that all forms of mercury are dangerous, in particular, methylmercury. What may not be clear is the direct relationship between the mercury emitted from power plants and its deposition locally and further afield [85]. Even if it may not be possible to trace the precise path of mercury emitted from a particular power plant to a specific lake or stream, mercury eventually finds its way into water bodies and the aquatic food chain. Just a tiny drop of mercury (1gram) – is enough to contaminate a small lake 25-acre (10 hectares) to the point where fish are unsafe to eat [86]. There need be no further delay to reduce mercury emissions significantly – the anthropogenic emissions of today remain for decades.

Capture the Pollutants – OR Prevent Pollution

Otherwise known as pollution control, the typical approach to decreasing emissions of harmful substances has been and continues to be the technological "chasing them down", or continue to release dangerous substances, **then** go after them. Clearly, coal itself is complex and varied in composition, depending on the location and age or type of coal and this complexity and variance pose difficulties for control technologies. Then again, while devices such as electrostatic precipitators and "baghouses" can collect some of the metals such as arsenic, beryllium, cadmium, chromium, lead, manganese and nickel, they are unlikely to retrieve much of the mercury. The very nature of this persistent volatile tricky pollutant allows it to elude many of the controls to date.

There are other choices for energy generation and mercury is well suited to be "the driver" to vigorously pursue these alternatives in conjunction with reductions in other pollutants. While fuel-switching to natural gas can be beneficial and reduce some of the emissions, it is nonetheless an option that relies on the burning of a fossil fuel and leads to other issues – it should not be seen as the panacea.

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[83] Coal-fired plants in Canada use pulverized coal technology that results in emissions of very fine particulate matter. Most of the mercury emitted from these utilities is associated with the discharge of flue gases.

[84] Bituminous and anthracite coals have the highest average mercury content Senes Report (Final Draft), Evaluation of Technologies for Reducing Emissions, March 31 1999

[85] Up to 10 percent of the mercury emitted into the air is deposited within 100 kilometers of a power plant, 50 percent within 1000 kilometers, and the rest is transported locally and globally ; Clean Air Network, Turn the Heat up on Dirty Power, March 1998

[86] National Wildlife Federation Fact Sheet, The Toll from Coal: Dirty Power threatens our Environment.

The continued reliance on fossil fuels embraces market strategies such as emissions trading and credits. These strategies are somewhat obscure in their assumptions and their merits as a motivating force for industry to reduce emissions are questionable. It is not buyer beware, but communities who must be aware of the buyer. Unless there are built in mechanisms that ensure real reductions in emissions and declining caps, emissions trading may very well be akin to second-hand smoke and take us down a very slippery slope that could create environmental "hotspots".

The choices for energy generation need to be gauged by the health, social, ecological and economic impacts on local communities and beyond and at the very least should incorporate conservation of energy and efficiency, full life cycle analysis of material source and political, legislative and financial support for a dedicated proportional shift from fossil fuels to renewable energy sources.

Coal - and the Coal Mines - Reflections from the Past

The history of coal mining is well known for its health effects on miners as well as in local communities. Coal-mining operations have polluted many rivers, streams and lakes with sulphur and other water-soluble minerals in coal as well as from mine tailings and leaching of toxic chemicals from coal piles. When mining operations shut down, it is primarily for economic reasons, certainly not for environmental or health concerns. These shutdowns are hardships for communities whose very livelihood is dependent on the survival of such operations. Along with loss of livelihood is loss of identity, pride and dignity. The demise of single industry-based communities underscores the need for diversity, conservation and sustenance of natural resources as basic to our well-being.

Seen from a distance in such weather, Coketown lay shrouded in a haze of its own… A blur of soot and smoke, now confusedley tending this way, now that way, now aspiring to the vault of heaven, now murkily creeping along the earth, as the wind rose and fell, or changed its quarter: a dense formless jumble, with sheets of cross light in it, that showed nothing but masses of darkness: Charles Dickens, circa 1850 Hard Times

While we may not have a "Coketown" today, a recurring and troublesome theme is operative today and is not unlike what Dickens expressed in his novel "Hard Times".

There never was such fragile china-ware as that of which the millers of Coketown were made. …they were utterly undone when it was hinted that perhaps they need not always make quite so much smoke. When it was proposed that they be held accountable for the consequences of any of their acts, they threatened to sooner pitch their property into the Atlantic, terrifying the Home Secretary on several occasions. However, they never had to pitch their properties. On the contrary, they took mighty good care of it. There it was, in the haze yonder; and it increased and multiplied.

A3. Fish - Canaries in a Coal Mine

Most health experts and food guides recommend fish as a tasty low-fat source of protein that can lower your risk of heart disease. The same sources may also warn you that certain fish may contain harmful pollutants and advise that you consult your fishing guide for more details [87]. Trophies are awarded for the largest catch of a certain species, but chances are, that trophy fish can't be eaten – it's full of poison and the chief contaminant is mercury.

Back in 1971, Marvin Gaye lamented in his song "Mercy, Mercy Ecology"

"Whoa, mercy, mercy me
Oh, things ain't what they used to be…
Fish full of mercury"

Almost thirty years later, we are still singing the same song.

New Brunswick Fish Advisory, 1999-2000

Pregnant women, nursing mothers, women who may become pregnant and children less than 8 years old should, as a rule, not eat fish from lakes and ponds in New Brunswick. Children older than 8 years of age, male adults and women past childbearing age, should limit consumption of all wild New Brunswick fish (except Brook trout) caught in New Brunswick lakes and rivers to one meal every two weeks.

(Conservation Council of New Brunswick)

Mercury
Its Pathway through the Food Chain

Mercury is a persistent toxic substance and indestructible, posing a direct threat to people and wildlife. Exposure to mercury can cause serious neurological and developmental damage to humans ranging from subtle but permanent losses of sensory or cognitive ability (e.g. walking, talking), to birth defects, tremors, and even death.

While mercury is present naturally in the environment, human activities such as incineration, coal-fired plants and industrial processes are by far the major contributors of mercury in the environment. Along with mercury released into water bodies, mercury is emitted into the air and falls to the earth in rain, snow and dry particles accumulating in lake and river sediments, in soil and fish.

The most common exposure route to mercury is through the consumption of fish contaminated with mercury. When mercury enters water, it is converted to its most dangerous form, methylmercury, by microbial organisms and is absorbed by plankton. As larger aquatic organisms feed on the plankton, the methylmercury concentrates in their tissues. Methylmercury bioaccumulates so efficiently in the aquatic food chain, that predator fish at the top of the food chain have concentrations millions of times higher in than levels found in surrounding waters [88].

[87] Canadian Food and Inspection Agency – Consumer Fact Sheet – Mercury and Fish Consumption, 1999
[88] This phenomenon, bioaccumulation or biomagnification, where lower organisms take up and store toxins such as mercury from the environment. Their predators in turn collect and retain the toxins in their tissues, building up higher concentrations, and so on throughout the food chain, with the result that the highest members of the food chain can have levels of methylmercury millions of times of that found in the surrounding waters. Most of the mercury found in adult fish is methylmercury.

Many lakes and rivers are now contaminated with mercury as well as other toxins. Acid rain exacerbates the mercury problem, since acidification increases the solubility and mobility of mercury and other toxic metals.

Mercury in Fish: Impacts on Humans

Concentrations of methylmercury found in many fish have reached a level where consumption of fish can pose threats to human health, particularly since it is the top predator species such as salmon, lake trout, or walleye are among the fish species that people are most like to catch and eat.

Most at risk from mercury contamination are women of childbearing age, children and fetuses, and communities where fish is a food staple and the predominant source of protein in the diet, a traditional food source, and an economic resource. Skinning or trimming does not reduce the concentration of mercury, nor is mercury removed by cooking processes.

When ingested by pregnant women, methylmercury readily crosses the placenta and targets the developing fetal brain and central nervous system, producing serious developmental delays in walking, talking, hearing and writing even in relatively tiny amounts. Other impacts include cerebral palsy and mental retardation at high exposure levels. Infants can also be exposed to high levels of methylmercury during breast-feeding.

Human Exposure - Safety in Numbers

The pervasiveness of mercury in fish has sparked the need for fish consumption guidelines to protect the most vulnerable populations at risk to mercury exposure. These guidelines indicate the level of mercury in fish below which fish are considered safe to eat without restrictions, or where caution is advised to limit or even avoid fish consumption. In United States, the guidelines are adapted from a standard reference level known as a “Reference Dose” (RfD). The RfD specifies the concentration of a chemical that is “safe” to ingest on a daily basis over a lifetime. The Reference Dose is based on a number of factors such as epidemiological studies, toxicological effects, safety factors, and the most vulnerable populations [89]. The United States Environment Protection Agency (US EPA) has set the Reference Dose (RfD) for methylmercury to be the daily intake over a lifetime at which no adverse health effects are expected to occur in the most sensitive populations [90].

[89] Mercury in Eastern Canada and the Northeast States, Proceedings for Conference, September, 1998 pp. 32-41

[90] Mercury Report to Congress, US EPA, 1997, based on epidemiological studies on methylmercury poisoning in Iraq in 1971-72.

The US EPA has set the RfD at 0.1 micrograms (one-millionth of a gram) of methylmercury per kilogram of body weight per day, (0.1 µg/kg$_{bw}$/day).

The RfD of 0.1 µg/kg$_{bw}$/day is the most cautious safety level of exposure that has been set to date. In comparison, the Agency for Toxic Substances and Disease registry in the US recommends a minimum Reference Dose three times the EPA level[91].

In Canada, Health Canada's mandate is to maintain and improve the health of Canadians and is responsible to ensure the safety of the food supply. The "Tolerable Daily Intake" (TDI) is used as its measure to assess risks associated with toxic substances such as mercury. To all intents and purposes, it is equivalent to the Reference Dose[92]. Health Canada recently revised downward the TDI for mercury for women of reproductive age and infants, but not for the general population.

In Canada, the *provisional* TDI (pTDI) is 0.2 µg/kg$_{bw}$/day of mercury for women of reproductive age and infants. The TDI for the general population is 0.47 µg/kg$_{bw}$/day.

Research on the effects of mercury on humans and the dose-response relationship continues. Studies are being conducted in the Faroe Islands in the North Atlantic, the Seychelle Islands in the Indian Ocean and in the Amazon among indigenous peoples[93].

- The Faroe Islands study found that children exposed to methylmercury as fetuses (due to pilot whale meat consumption by their mothers) showed mercury-related problems in the areas of language, attention, and memory. The researchers concluded that these effects are due to prenatal methylmercury exposure and were occurring at exposure levels currently considered to be "safe" by the U.S. EPA.

- Indigenous peoples in the Amazon exposed to mercury used in gold mining industries reported neurological deficits in motor function, attention and visualspatial performance.

- An ongoing study in the Seychelle Islands indicates less significant effects, and conflicts with the Faroe Islands study and earlier findings in Iraq (and New Zealand). Note: The Seychelle Islands study is not used in the US EPA reference dose.

Reference Doses and TDIs are intended to be cautious and protective of the most sensitive populations over the span of a lifetime. Their different values lies in the assumptions and other factors made in their determination.To no surprise, this leads to confusion and opens the door to challenges. The lower the value, the more cautious, and that tends to upset some industries who feel "threatened" that they may actually be required to take measures that would reduce mercury emissions.

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[91] In July 2000, the US National Academy of Sciences justified upholding the EPA RfD of 0.1µg/kg/day on the basis of the Faroe Islands study as the most appropriate to protect the most sensitive populations.
[92] RfDs are based on methylmercury, in consideration that 90% of mercury is in the methylmercury form, while TDIs are based on mercury as well as methylmercury.
[93] National Wildlife Federation, Clean the Rain, Clean the Lakes, Mercury in Rain is Polluting the Great Lakes Report, p.7

At the present rate, rising levels of mercury in areas such as the Great Lakes would still be many times higher than any safe level so far contemplated by the US EPA [94].

A Glossary of Fish Advisories:

Reference Doses and TDIs are guidelines used to determe fish consumption limits. Fish advisories are usually triggered when the concentration of toxic substances in fish tissue in parts per million (ppm) exceeds these guidelines [95]. Their intent is to inform the public of the potential need to restrict fish consumption as a result of high concentrations of toxic substances. Mercury is by far the toxic substance responsible for most advisories. The advisories may recommend either limiting or avoiding consumption of fish and may be specifically directed to sensitive populations and/or the public at large [96]. To date, 40 states and one territory in the U.S. and 7 provinces in Canada issue fish advisories.

Advisories do not follow the same ground rules for a number of reasons that may relate to the significance of recreational and commercial fishing, the political and economical climate as well as the extent of testing and awareness of the environmental and health issues plays a role. Here is a sampling of some advisories:

United States: The US Food and Drug Administration (FDA) limit for methylmercury in commercial fish is 1.0 ppm.

Sweden: The objective is to reduce mercury in fish to 0.5 ppm by reducing (anthropogenic) emissions of mercury.

Canada: Health Canada guideline for total mercury content: 0.5 ppm (commercial marine and freshwater fish) for adult population.

Ontario: Consumption restrictions for sport fish containing mercury begin at levels above 0.45 ppm; restricted consumption for children under 15 years of age and women of childbearing age (based on provisional TDI set by Health Canada); total restriction advised for mercury levels greater than 1.57 ppm [97].
New Brunswick: (1999-2000) Pregnant women, nursing mothers, women who may become pregnant and children less than eight years old, should, as a rule, not eat fish from lakes and ponds in New Brunswick.

[94] National Wildlife Fund, Clean the Rain, Clear the Lakes, Mercury is Polluting the Great Lakes September, 1999
[95] Calculation: assuming 60-kg adult, 90% of mercury in fish is in methylmercury form, 4 fish meals a month, each 227 gm.
[96] EPA recommends that in order to be most protective of human health, it is safe to assume that all mercury is present as methylmercury in the determination of fish advisories.
[97] Ministry of Environment, Guide to Eating Ontario Sport Fish, 1999-2000

If this isn't confusing enough, there's more….

Exempt Species - A Unique Solution

Health Canada has exempted swordfish, shark, and tuna from mercury restrictions on the basis that these species are **"gourmet"** food products. "These species are large predators and therefore tend to have higher levels of methylmercury than other fish. Since they are exempted from mercury restrictions, they are no longer tested for mercury content **unless they are being exported**."[98]

Tuna Confusion

- An 8-ounce (227) gram tin of tuna contains enough mercury to exceed EPA's recommended daily consumption for an adult.

- Some states warn sensitive populations not to eat more than 7 ounces [200 grams] of canned tuna per week, provided that no other mercury-contaminated fish is consumed over the same period. (On average, canned tuna mercury levels are one-third of those levels often found in fresh or frozen tuna, which typically exceed 1.0 ppm.)

- The environmental group, Clean Water Action, has calculated that the average mercury level in tuna is high enough that eating as little as 2 ounces (or about 50 grams) of tuna a week would be unsafe for a child weighing under 35 pounds (16 kg). Another recent report has warned pregnant women to avoid canned tuna due to mercury contamination risks [99].

- Testing of dozens of seafood samples from both Canadian and foreign sources have found that the tuna samples contained enough mercury to put women over the new daily limit by eating only a few mouthfuls a day.

Further Indicators of a Problem

- In more than 50,000 bodies of water in 40 states in the U.S., fish contain such high levels of mercury that health agencies have warned people against eating them.

- About 7 million women and children in the U.S. are consistently eating mercury-contaminated fish at levels higher than what EPA would consider safe.

- As many as 85,000 U.S. women of childbearing age in a given year have been exposed to elevated methylmercury levels sufficient to affect the brain development of their babies. Recent studies from the U.S. Center for Disease Control and Prevention put this figure upward to about 375,000.

- As many as 3 million children in the U.S. have elevated blood mercury levels [100].

[98] Canadian Food and Inspection Agency – Consumer Fact Sheet - Mercury and Fish Consumption, 1999
[99] Environmental Working Group and Health Care Without Harm, May, 1999
[100] National Wildlife Federation, www.nwf.org/greatlakes

- EPA estimates that every year about 1.6 million people in the US are eating sufficient amounts of fish and shellfish to place them at risk. This number includes 85 000 pregnant women, 880 000 women of childbearing age and 665 000 children.

- The US Federal Drug Agency (FDA) issues safety levels for mercury in commercially sold marine fish and shellfish based on adult populations that are different from EPA for sport-fish.

- Both Canada (Health Canada) and the US advise the public to limit consumption of swordfish, shark and tuna (fresh, frozen) to one meal per week, and for children and women of childbearing age to one meal per month.

- The concentration of mercury in rain in the Great Lakes Region has increased by about 8 per cent a year over the last 5 years, further adding to the mercury load [101].

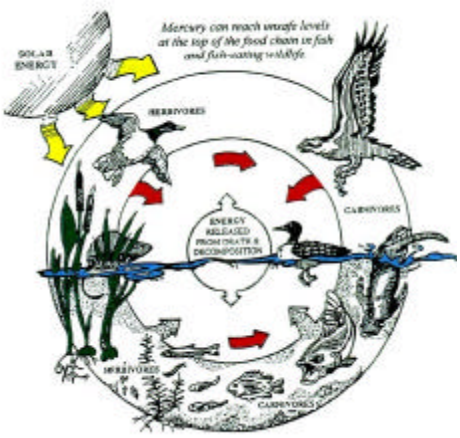
Fish consumption advisories are now a routine part of our lives, much like smog advisories. And just like smog advisories, they are increasing in number. While they may serve some purpose in alerting and protecting those who observe such advisories, they are limited in scope, not consistent, and confusing. Here are some questions to consider.

> How well are fish advisories being followed?
> How aware is the public of their existence - do they know of the greater restrictions to women of childbearing age and nursing mothers [102]?
> Do these advisories adequately reach the most sensitive populations?
> Are federal governments providing the public with enough information to make informed decisions? Are they protecting the future generations?
> What are the governments doing to bring down emissions of mercury and other dangerous substances, other than token mediocre talked-about reductions?

Fish advisories raise a red flag for human consumption. On the other hand, protection for fish and wildlife is wanting. Clearly ***fish have become the canaries in a coal mine.***

[101] National Wildlife Federation, Clean the Rain, Clear the Lakes report, September 1999.
[102] In Maine, only 3% level of awareness was noted.

Mercury in Fish: Impacts on Wildlife [103]



Mercury absorbed by fish from food and water can cause a host of problems, from impaired sperm generation in guppies to high mortality among rainbow trout embryos.

The accumulation of mercury in fish populations has far-reaching effect on other species. Wildlife at the high end of the food chain, particularly those feeding off top predator fish, is most severely impacted. Predatory mammals (panthers), marine mammals (whales and seals), and predatory birds (hawks and eagles) are most at risk [104]. Mercury damages their livers, kidneys, most particularly, the central nervous system of these animals with the most devastating effects in embryos and the young and is the likely cause of reproductive failure among loons, eagles, mink, turtles, river otters, and other wildlife.

Mercury levels in loons appear to increase from west to east across North America [105]. In Maine, mercury in loons has caused reproductive problems and limited their ability to fight off disease. Emaciated loons recently found dead or in a weakened state in eastern Canada had mercury levels associated with reproductive impairment and toxicity [106]. Elevated levels of methylmercury in loons nesting on acidified lakes were found in Wisconsin.

Other fish-eating waterfowl are affected as well. For example, moderately high levels of mercury have caused reduced hatching success and duckling survival in mallards and American black ducks.
Mercury is suspected as a contributor to limb abnormalities among frogs and other amphibians. Scientists now believe that methylmercury is a factor in the increasing incidence of deformities among species such as bullfrogs and northern leopard frogs[107].

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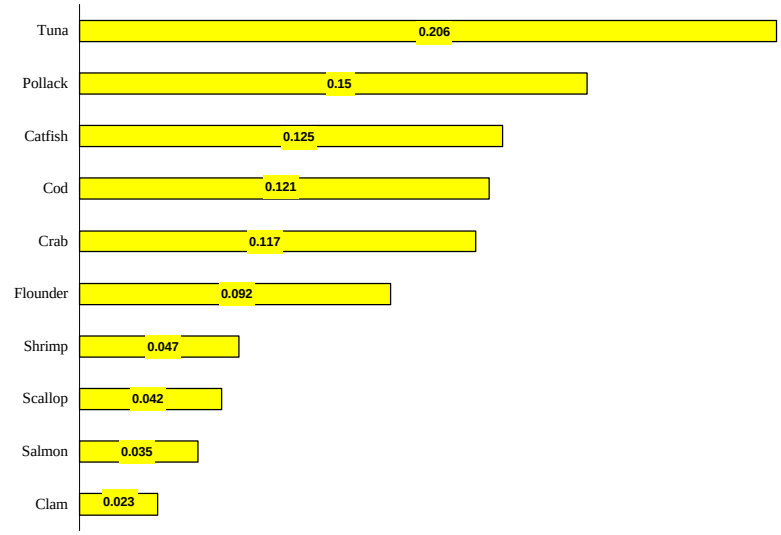
[103] Sketch from New Brunswick Conservation Council Paper – Mercury Contamination of the St. John River Food Chain, 2000.
[104] High mercury levels have been identified in free-roaming Florida panthers, especially those with a diet rich in raccoons, rabbits, armadillos, and alligators. Scientists now think that chronic exposure to mercury may be partly responsible for lower than expected population densities of panthers in much of their range and may actually be contributing to the extinction of these highly endangered animals.
[105] Loons in Alaska have much less mercury in their bodies than those found in the Great Lakes basin and New England.
[106] National Wildlife Federation, Clear the Rain, Clear the Lakes Report P. 8
[107] National Wildlife Federation, Great Lakes Natural Resource Center, www.nwf.org/greatlakes

Some Fish Facts

Mercury Levels in Fish[108]

(Note: The daily-ingested level considered safe by EPA is micrograms/kilogram (ppm) of body weight)

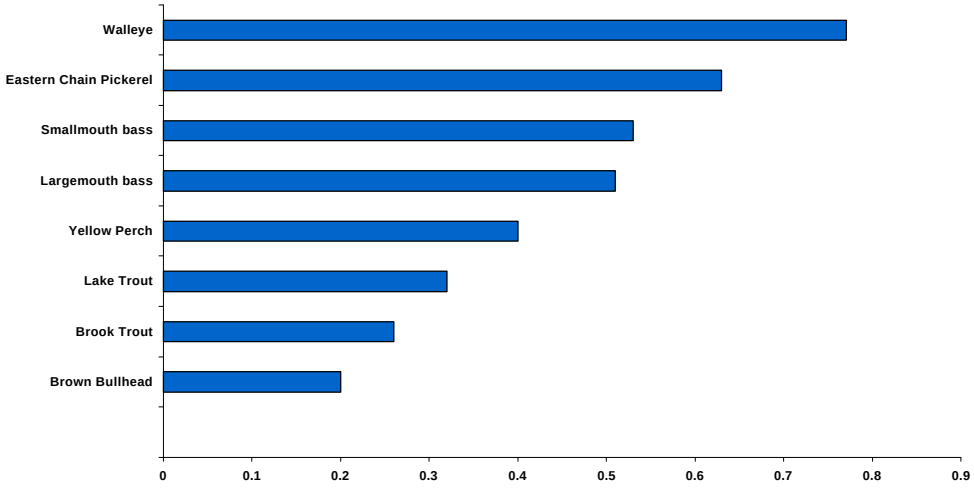
Ten common fish types and their average mercury concentrations in micrograms/gram wet weight (parts per million, ppm)



Mercury in Freshwater Sport Fish

(Northeastern states and eastern Canadian provinces) [109]

Average Concentrations in ppm



Marine Fish (average mercury concentrations, ppm)
Atlantic shark - 0.88
Bluefish tuna - 3.41
Sea bass - greater than 0.5

[108] Clean Air Network, Turn Up the Heat on Dirty Power, March, 1998

[109] US EPA Fact Sheet, Mercury Update: Impact on Fish Advisories, September 1999

Current RfDs and TDIs: [110]

Country/Agency	Recommended Reference Dose micrograms mercury per kilogram body weight per day ($\mu g/kg_{bw}$/day)	Comment
U.S.EPA	0.1 $\mu g/kg_{bw}$/day (methylmercury)	reference dose (revised in 1995 to be protective of the fetus)
U.S. Agency for Toxic Substances and Disease Registry (ATSDR)	0.3 $\mu g/kg_{bw}$/day (methylmercury)	subject to revision
Canada: Health Canada TDI	0.47 $\mu g/kg_{bw}$/day (mercury) or 0.2 $\mu g/kg_{bw}$/day *	General population *Provisional, considered safe for women of childbearing age and children under 10
World Health Organization TDI	0.47 $\mu g/kg_{bw}$/day - methylmercury 0.71 $\mu g/kg_{bw}$/day - mercury	For general population

[110] US EPA Fact Sheet, Mercury Update: Impact on Fish Advisories, September, 1999: Mercury in Eastern Canada and the Northeast States, September, 1998

Appendix B Mercury – Human Health Effects

B.1 Sources, Absorption, Metabolism, Excretion and Toxicity

Introduction

Mercury is a known pervasive environmental toxin that causes a wide range of adverse health effects in humans. While mercury is a naturally occurring metal, industrial activities along with the numerous uses of mercury for various applications have led to dramatic increases in levels of mercury in the atmosphere globally.

Exposure to mercury most typically occurs by inhalation or ingestion. The most significant sources of inhaled mercury are industrial air emissions from incinerators, coal-fired plants and other industrial activities. Mercury is also considered an indoor air pollutant, as a result of spills of elemental mercury from instruments found in the home or workplace.

Mercury emitted into the atmosphere is eventually deposited in lakes, rivers and streams, whereupon it is readily converted by micro-organisms in water and soil sediments to methylmercury, the most toxic form of mercury to humans. Fresh-water and ocean fish accumulate and concentrate methylmercury at high levels in their tissues that can be hundreds of thousands of times greater than levels in the surrounding water. Humans are most readily exposed to methylmercury by eating fish contaminated with methylmercury.

Toxicity depends on the dose received, the route of exposure, and the chemical form. The brain, kidney, reproductive systems and developing fetus are the primary targets. Precise symptoms and effects are wide-ranging and depend on a number of factors. Of particular concern are acute and chronic exposures to mercury, particularly for the most vulnerable populations, children, women of child-bearing age and communities whose traditional diet is heavily reliant on fish. The developing fetus and young children are most at risk to the effects of exposure to mercury, since its presence can disturb many aspects of development, in particular, brain maturation.

Forms of Mercury:

Mercury occurs in 3 forms (elemental, inorganic, and organic), each of which has unique characteristics with respect to solubility, reactivity, biological effects, and toxicity.

1. **Elemental Mercury** – the metallic element (Hg^0), a shiny silver liquid or a colourless, odourless gas vapour at room temperature, also referred to as quicksilver or metallic mercury
2. **Inorganic Mercury** – mercury in combination with other elements such as sulphur, chlorine, oxygen (Hg^{1+} [mercurous salts] and Hg^{2+} [mercuric salts]); and
3. **Organic Mercury** – mercury compounds that include carbon, such as methylmercury (CH_3-Hg), ethylmercury, and phenylmercury.

A more detailed description of each form with respect to source of exposure, absorption, metabolism and excretion, and toxicity is given in the following section[111].

Elemental Mercury

Sources

The main anthropogenic sources of atmospheric mercury vapour are from combustion sources such as coal-fired plants from burning fossil fuels; chloralkali facilities; mining and smelting; incinerators (especially medical waste); and crematoriums. Some of the more common products that use elemental mercury in liquid form include thermometers, blood pressure gauges and other instruments, dental amalgam, fluorescent light fixtures, batteries, electrical equipment, and fungicides. Both elemental and inorganic mercury have been used in folk remedies and rituals around the world.

Dental amalgam, a composite metal that is about 50% mercury, has been used to fill decayed teeth since the 1820s. Exposure to small amounts of metallic mercury results from the vapours that are released from dental fillings.

Other possible routes of exposure to metallic mercury through inhalation can occur in the household and workplace as a result of spills from the breakage of items containing mercury such as thermometers and fluorescent lamps.

The indiscriminate disposal of mercury-containing products items when buried in landfills or burned in waste incinerators, is a major source of mercury contamination in the environment. Hazardous waste sites and occupational exposures in some manufacturing industries (metal processing and electrical equipment industries) may put certain populations at risk of acute mercury poisoning.

Absorption, Metabolism, and Excretion

Elemental mercury readily vaporizes at room temperature. When inhaled, elemental mercury vapor easily passes through pulmonary alveolar membranes and enters the blood, where it distributes primarily to the red blood cells, central nervous system (CNS), and kidneys[112]. Elemental mercury in contact with tissue oxidizes to mercuric ion, which does not cross the blood-brain barrier well. However, when elemental mercury is converted to the mercuric form within the CNS, it is less able to diffuse out of the brain. Elemental mercury also crosses the placenta and concentrates in the fetus.

In adults, the half-life of elemental mercury is 60 days (range: 35-90 days); excretion is primarily fecal, though some is exhaled.

[111] Lynn R. Goldman, MD, MPH; Michael W. Shannon, MD, MPH; and the Committee on Environmental Health, Technical Report, Mercury in the Environment: Implications for Pediatricians, Volume 108, Number 1, July 2001, pp 197 - 205

[112] Less than 0.1% of elemental mercury is absorbed from the gastrointestinal tract after ingestion, so it has little toxicity when ingested. Minimal absorption occurs with dermal exposure.

Toxicity

At high concentrations, mercury vapor inhalation produces acute necrotizing bronchitis and pneumonitis, which can lead to death from respiratory failure. Fatalities have resulted from heating elemental mercury in inadequately ventilated areas. Long-term exposure to mercury vapor primarily affects the CNS. (The "Mad Hatter," a character in the book *Alice in Wonderland*, was based on the brain disease that commonly affected hat makers who used liquid mercury as a treatment for hat felt.)

Early nonspecific signs include insomnia, forgetfulness, loss of appetite, and mild tremors, which may be, misdiagnosed as psychiatric illness. Continued exposure leads to progressive tremor and erethism, a syndrome characterized by red palms, emotional lability, and memory impairment. Salivation, excessive sweating, and hemoconcentration are accompanying autonomic signs. Mercury also accumulates in kidney tissues, directly causing renal toxicity, including proteinuria or nephrotic syndrome. Mercury exposure from dental amalgams has provoked concerns about subclinical or unusual neurologic effects ranging from subjective complaints, such as chronic fatigue, to demyelinating neuropathies, including multiple sclerosis.

Inorganic Mercury Compounds

Sources

Inorganic mercury compounds (salts) have antibacterial, antiseptic, cathartic, and diuretic properties. Examples of inorganic mercury salts are mercurous chloride (calomel) and mercuric oxide. Inorganic mercury has been used in a number of consumer products ranging from teething powders to skin lightening creams. While its use has been banned in Canada and the United States, these products are still available on the world market.

Absorption, Metabolism, and Excretion

Although only about 10% of ingested mercury salt is absorbed, ingested mercury salts tend to be extremely caustic. A small amount of dermal absorption occurs as well. In adults, the half-life is about 40 days. Excretion is mostly fecal. With chronic exposure, urinary excretion is somewhat greater.

Toxicity

Absorption of ingested mercury salts can be fatal. Ingestion is usually inadvertent or with suicidal intent. Gastrointestinal ulceration or perforation and hemorrhage are rapidly produced, followed by circulatory collapse. Breakdown of intestinal mucosal barriers leads to extensive mercury absorption and distribution to the kidneys. Mercury salts are very toxic to the kidneys, causing acute tubular necrosis, immunologic glomerulonephritis, or nephrotic syndrome. Central neuropathy can also occur from mercury salt exposure. Acrodynia (painful extremities), also known as pink disease, seems to be a hypersensitivity response to mercury and was initially reported among infants exposed to calomel teething powders containing mercurous chloride (cases also have been reported in infants exposed to the organic mercury compound phenylmercury used as a fungicidal diaper rinse and in children exposed to mercury in interior latex paint). A maculopapular rash, swollen and painful extremities, peripheral neuropathy, hypertension, and renal tubular dysfunction develop in affected children. Individual susceptibility is poorly understood.

Organic Mercury Compounds

Sources

Organic compounds include methylmercury, ethylmercury, and phenylmercury. These agents have been produced as industrial compounds, primarily biocides and pesticides. Organic mercury compounds are also found in common household antiseptics: Mercurochrome (merbromin) and Merthiolate (thimerosal).

Methylmercury is the predominant form of organic mercury found in the environment. Generally, methylmercury in the environment is formed by microorganisms from elemental mercury deposited from the air into water and soil or discharged directly into water from natural or human sources. Consumption of fish is the primary route of exposure to organic mercury for children. The methylmercury content of fish varies by species and size of fish and harvest location[113]. Methylmercury has also been used as a fungicide on seed grains and is a component of industrial waste[114].

Ethylmercury, in the form of thimerosal contains about 50% mercury by weight. It was formerly used as a topical antiseptic and has also been used as an effective preservative for killed vaccines and other biological agents for medical therapy. Before fall 1999, there was 25 µg of mercury in each 0.5-mL dose of most diphtheria and tetanus toxoids and acellular pertussis vaccines as well as some *Haemophilus influenzae* type b, influenza, meningococcal, pneumococcal, and rabies vaccines. In addition, there was 12.5 µg of mercury in each dose of the hepatitis B vaccine[115]. Assuming that the toxicity of ethylmercury is similar to that of methylmercury, the exposure from a single vaccination could potentially exceed US federal guidelines for that day [116]. Thimerosal used to irrigate the external auditory canals in a child with tympanostomy tubes has caused severe mercury poisoning.

In the United States, phenylmercury (phenylmercuric nitrate or acetate) was used in latex paint as a pesticide (to prevent mildew growth on walls) and paint preservative (to prevent paint discoloration from growth of microorganisms). Phenylmercury and ethylmercury continue to be used as bacteriostatic agents for various topical pharmacologic preparations. Dimethylmercury, a form of organic mercury used only in research laboratories, is highly toxic, causing death after extremely small exposures.

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[113] The top 10 commercial fish species (canned tuna, shrimp, pollock, salmon, cod, catfish, clams, flatfish, crabs, and scallops), which represent about 85% of the seafood market, contain a mean mercury level of approximately 0.1µg/g.
[114] Grain 'accidentally' treated with a mercury fungicide was eaten by people in Iraq during a famine in the 1970s, resulting in the death of hundreds of people and effects on the unborn from mercury poisoning.
[115] The reference doses* established by federal agencies were between 0.1 and 0.4 µg/kg/d.
[116] Currently in the US, all vaccines in the recommended childhood immunization schedule do not contain thimerosal as a preservative. With routine immunization, a cumulative dose of up to 75 µg of mercury by 3 months of age and 187.5 µg by 6 months of age could have been received.

Absorption, Metabolism, and Excretion

Most organic mercury compounds are readily absorbed by ingestion and inhalation and through the skin, except for phenylmercury. In general, organic mercury compounds are lipid soluble, and 90% to 100% is absorbed from the gastrointestinal tract. They appear in the lipid fraction of blood and brain tissue. Organic mercury readily crosses the blood-brain barrier and also crosses the placenta. Fetal blood mercury levels are equal to or higher than maternal levels. Methylmercury appears in human milk.

The mean half-life for methylmercury in blood is 40 to 50 days (range: 20-70 days) for adults. Ninety percent of methylmercury is excreted through bile in feces. Phenylmercury is rapidly metabolized. Its effects are similar to those of mercury salts.

Toxicity

The toxicity of organic mercury compounds is dependent on specific compound, route of exposure, dose, and age of the person at exposure. Organic mercury compounds are most toxic in the CNS, though the kidneys and immune system may also be affected. Signs of toxicity from acute exposure progress from paresthesia and ataxia, generalized weakness, visual and hearing impairment, tremor and muscle spasticity, to coma and death. Generally methylmercury and ethylmercury are more toxic than phenylmercury, because they are metabolized more slowly in vivo.

In the developing brain, methylmercury is toxic to the cerebral and cerebellar cortex, causing focal necrosis of neurons and destruction of glial cells. Methylmercury is a known **teratogen** in the fetal brain, interfering with neuronal migration and the organization of brain nuclei and layering of the cortical neurons.

In the Minamata Bay disaster and the Iraq epidemic, mothers who were asymptomatic or showed mild toxic effects gave birth to severely affected infants. Typically, infants appeared normal at birth, but psychomotor retardation, blindness, deafness, and seizures developed in time. Effects at low doses include neuro-toxic effects, especially in children exposed in utero[117]. Further evidence indicates likelihood of effects on cardiovascular, immune and reproductive systems.

[117] The National Academy of Sciences (NAS) estimates that more than 60000 U.S. babies born each year are at risk for neuro-developmental effects of methylmercury. Other sources place the number of babies potentially at risk to be in the order ranging from 180000 (US EPA, Ellen Brown, January 22, 2001 Mercury is a Public Health Issue) to 375000 (Centers for Disease Control and Prevention (CDC, US)).

B2. Dental Amalgam – A Health Risk

Dental amalgam, an alloy consisting of approximately 50 per cent mercury, 35 per cent silver, 13 per cent tin, 2 per cent copper, and trace amounts of zinc has been used for tooth fillings as early as the 1820s. Known for its low cost, durability and ease of placement, amalgam is the filling material favoured by most dentists, who maintain that mercury fillings last longer than composites and are gentler to tooth pulp. On an annual basis, North American dentists install approximately 170,000 kilograms of mercury.

Around the same period in the 19th century when the use of amalgam was introduced, mercury was also known for its toxicity. It is cytotoxic (causing death to cells) and neurotoxic (toxic to brain cells and the central nervous system), capable of penetrating all living cells of the human body. Mercury is also an enzyme inhibitor that disrupts cellular repair and DNA replication. The effects of low-level exposure to mercury over a long period of time are subtle and not well recognized. As well, the threshold level, that is, the smallest amount of mercury that won't damage human cells is unknown.

A recently published Calgary study showed that mercury could cause neurodegeneration in animals by arresting the ability of tubulin, the protein that acts to linking cells together[118]. Similar damage can also be found in the brains of Alzheimer's patients. The concentrations of mercury vapour used in the study were equivalent to that found in people with a dozen or more mercury amalgam fillings. Amalgams may have an adverse effect on the immune system's T-lymphocyte count.

Low concentrations of mercury vapour are constantly released from amalgam fillings and can account for as much as 70 per cent of mercury ions found in human urine. Several clinical studies have reported altered neurobehaviour in dental personnel, possibly due to chronic exposure to low level mercury vapour. Neuropsychological dysfunction was found in 90 per cent of dentists tested. Female dental personnel had a higher spontaneous abortion rate, higher incidence of premature labour and elevated perinatal mortality[119].

Mercury has been shown to migrate from the teeth into nearly all body tissues, especially the brain, kidneys and liver[120]. Levels of mercury have been found to be three times higher in the brain and kidney tissue of subjects with mercury amalgams. Routine repetitive actions such as chewing, brushing, or grinding teeth are able to cause absorption of mercury from amalgam fillings.

Mercury exposure from dental amalgam has provoked concerns about subclinical or unusual effects ranging from subjective complaints, such as chronic fatigue, to demyelineating neuropathies, including multiple sclerosis[121]. A dentist in Colorado who himself has MS, treats MS victims and people with other chronic health problems by removing mercury amalgam fillings. He claims that 80 to 85 per cent of his patients improve significantly, and says that if his results are to be written off as "anecdotal" or

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[118] Exposure to mercury vapours equivalent to that from a dozen tooth fillings breaks down brain neurons in animals (Christopher C.W. Leong, Naweed I. Syed and Fritz L. Lorscheider of the University of Calgary, journal NeuroReport)

[119] . Dr. Sandra Denton, who specializes in treating chronic mercury toxicity, cites a study at the University of North Texas that found neuropsychological dysfunction in 90 per cent of dentists tested

[120] Murray Vimy, a dentist and professor at the University of Calgary

[121] A Danish study found that multiple sclerosis (MS) patients had eight times higher levels of mercury in their cerebrospinal fluid than healthy controls. Dentist Hal Huggins, of Colorado Springs, Colo. Is afflicted with MS.

"placebo effect," then he has the largest collection of sustained recurring anecdotal placebo responses in the world.

Despite claims by the ADA that amalgams have been proved safe in studies, no studies have been produced that support such claims. On the other hand research documenting mercury toxicity is voluminous.

The Canadian Dental Association (CDA) insists there is no scientific evidence linking medical illness symptoms to mercury fillings, except relatively rare allergic sensitivity to mercury, and by and large there is no apparent epidemic of ill-health effects in patients who in total have billions of mercury amalgam fillings. However, since so many people have mercury fillings, no effective "control" group exists.

The reluctance of dental associations to acknowledge the health risk of mercury toxicity from amalgam fillings is unacceptable, especially when considering that diseases like multiple sclerosis, chronic fatigue syndrome and Alzheimer's can be linked to mercury exposure from tooth fillings[122].

Interestingly, scrap dental amalgam is classified hazardous waste by the U.S. Environmental Protection Agency, and by law must be stored in unbreakable, sealed containers and handled without touching. Yet the same material is considered non-toxic when introduced in the mouth where it is intended to remain for years.

[122] Excerpts from The Hamilton Spectator, Charles Moore "More evidence that mercury fillings are a danger" August 9, 2001

B3. Methylmercury Poisoning

Documented Cases: "Occupational Exposure"

In 1863, two chemists who were using an organic form of mercury (dimethylmercury) developed mercury poisoning and died. The nature of their deaths remained virtually unknown until 1940, when two scientists, Hunter and Russell, described methylmercury inhalation and mercury poisoning exhibited in four workers from a factory that produced mercurial fungicide agents for cereals.[123] An autopsy of one worker revealed neurological destruction and cerebral atrophy with loss of vision. Methylmercury poisoning became known as Hunter-Russell syndrome[124].

In the 1950's, reports of poisoning from non-occupational sources appeared with increased frequency, including a few cases of treatment of fungal skin infections as well as accidental and suicidal ingestion. Several large incidents of human poisoning occurred in the 1950s and 60s in Iraq, Pakistan and Guatemala as a result of ingesting flour and wheat seed treated with methylmercury compounds as fungicides. These compounds were used in Europe and North America as an economical and effective treatment in suppressing cereal infections such as bunt disease and thereby increasing crop yields [125]. It was initially assumed that these outbreaks or incidences of poisoning were due to careless handling and posed no danger to the general population. However, in the 1960s, the potential of methylmercury for ecological damage was illustrated by reports of the devastated populations of large birds [126]. The initial premises of careless handling or occupational exposure could not garner any further support. The general public was at risk.

"Accidental" Methylmercury Poisoning

The Iraqi Outbreak – for the record

The "Iraq Outbreak" of the early 1970s is the most extensive recorded episode of mercury poisonings that stem from contamination of breads made from grains treated with mercury fungicides. Ironically, the catastrophe in Iraq serves as a base for studies to assess risks to human health and as the basis for fish advisories to this day. While it has become a case study of major significance, the "Iraqi outbreak" has been objectified to the point where the personal human element and the appalling degree of destruction of lives and communities have been reduced to mere "statistics" for the record.

Iraqis were exposed to methylmercury primarily by eating breads prepared from grain seed, namely wheat and barley, imported from North America. The grain had been treated with a methylmercury fungicide[127]. As much as 100,000 tonnes of this grain was imported

[123] Powell PP. Minamata disease: JR Soc Med, 1990:83:84:1352-8.
[124] These earliest cases of methylmercury poisoning have been attributed to occupational exposure following the introduction of methylmercury compounds as antifungal seed dressing agents.
[125] Thomas Clarkson; Mercury: Major Issues in Environmental Health, Environmental Health Perspectives, vol. 100, pp.31-38, 1992
[126] Birds and small animals that in turn were consumed by predators such as eagles, hawks and owls consumed seeds contaminated with methylmercury, who were ultimately poisoned.
[127] Bakir et al., University of Baghdad, Clarkson, University of Rochester; Methylmercury Poisoning in Iraq, Science Vol 181 #1, 1973

in the fall of 1971, after the normal planting season, which had been hampered by a severe draught. Red dye had been added to the wheat and grain, presumably to indicate treatment with methylmercury fungicide. The grain was distributed to all provinces of Iraq, delivered to local granaries and in turn distributed to the farmers. It is likely that the bread consumption began in October of that year. Deliveries of the grain may have continued well into January of 1972, when authorities first issued warnings about the danger of eating the contaminated bread. Not until the end of March were the first samples of wheat and barley analyzed for the presence of methylmercury and the high degree of toxicity of the bread confirmed [128].

During the outbreak, from February to August of 1972, cases of serious brain damage and delayed walking were noted in children whose mothers were pregnant. Throughout the entire country, approximately 6000 Iraqis were admitted to hospitals suffering from methylmercury poisoning and of those admitted, about 500 died. These numbers may not convey the extent of the poisoning and fatalities. Indeed, epidemiological studies in the mid 1980s have estimated that 5000 people may have dies outside of hospitals with another 5000 eventually displaying severe symptoms of poisoning [129].

Mercury poisoning often does not reveal itself for weeks, months or even years after invading the body. Signs of poisoning occur only as the brain and nervous system actually become damaged usually in area related to sensation and motor functioning. Many Iraqis ate what would become fatal doses but did not experience any effects for weeks or months.

While consumption of homemade bread was the predominant cause of poisoning, many other food sources that would naturally depend on grain were laced with methylmercury and hence contaminated. This latent period may have given farmers a false sense of security. As no effects were observed in a few days, farmers felt safe to use the grain to feed livestock and to spread the grain on fields. Animals were fed the treated barley. Vegetation was stored in sacks that contained the treated grain or grown on soil contaminated with mercury. Game birds fed on the grain sown in fields. Farmers dumped grain into rivers, canals and lakes, effecting fish and drinking water. Maternal milk would have been contaminated. Farmers and granary workers would have inhaled or come in contact with mercury through dusts generated by grinding of wheat or sowing of grain.

The mercury poisoning in Iraq has been characterized as a “mistaken” or “accidental” use of methylmercury-treated grain in making homemade bread [130]. Yet several questions come to mind in reviewing the Iraqi outbreak today. The incident, known as the “Iraqi Outbreak”, may require reexamination in light of many questions that may never been asked, let alone unanswered.[131]

- From where was the grain shipped? Why was it shipped after the growing season?

[128] “Mercury Rising”, report by Ashbury Park Press, 1994.
[129] M.R. Greenwood, Methylmercury poisoning in Iraq - an epidemiological study of the 1971-72 outbreak. J.App. Toxicology 5: 148-159 (1985)
[130] CEC, P.35. Case Study
[131] Summary of Iraq and Seychelles Islands Studies – Response to Questions

- How were the Iraqi people notified about the treated grain, if at all? Indications are that the seeds, delivered to every region in Iraq, had been dyed red for identification and the sacks were labeled in Spanish – warning people not to eat the contents. [Note: the red dye could be removed by washing, possibly giving the impression that the "poison" could be removed or washed away.]

- It is probable that many people may not have gone to hospital for treatment. Do we really know how many were affected with mercury poisoning?

- To what degree may the latency period have masked the disease, leading to unreported incidences?

- Who has followed the lives of those affected in the aftermath of the outbreak? What has happened to the children born at the time and the others who fell ill during and after the outbreak?

- What, if any, compensation has been offered to the people and families affected?

The "Iraqi outbreak" sends a clear message and reminder of what can go wrong by not following due diligence and by continuing activities that prolong the presence of a persistent bioaccumulative toxin such as mercury in our environment. It speaks volumes of social disparity and environmental injustice.

Minamata Disease

Introduction

"Minamata disease" is synonymous with the episode of methylmercury poisoning that occurred in May 1956 in Minamata City. The poisoning stemmed from a chemical plant in Minamata owned and operated by Chisso Corporation. This plant, an acetaldehyde manufacturing facility, released methylmercury compounds in its wastewater that in turn was discharged into Minamata Bay [132]. The communities located in the area of this large ocean bay traditionally relied on fish as main dietary sources and consequently ate the poisoned fish and shellfish.

The subsequent effects of the spill led to a large-scale disaster of catastrophic proportions that would continue to haunt the inhabitants for decades to come. Many residents in the area developed symptoms typical of methylmercury poisoning, such as sensory disturbances, visual impairment, auditory disturbances and tremors and extensive lesions of the brain. Fetuses were poisoned. With the passage of time, the number of grave cases with acute methylmercury poisoning in the initial stage declined while the numbers of chronic patients who manifested symptoms gradually increased. For the past 36 years, of the 2265 patients who have been officially recognized as having methylmercury poisoning, 1435 have died. These numbers remain the source of much controversy.

Japan's Mercury Pollution Case

An Accounting of Government and Corporate Failure [133]

Minamata Disease is Japan's first recorded case of modern industrial pollution. Its history is a classic case of government ineptness in its unwillingness to take action and of corporate effrontery. The delays on the part of government and the Chisso Corporation to acknowledge the source of Minamata Disease and to seek resolution have exacerbated the suffering of so many, and of itself, has been a source of additional victimization.

One year after the initial outbreak, the Chisso Corporation had known that its acetaldehyde facility was releasing methylmercury into Minamata Bay and the Minamata River. It also knew that the exposure to methylmercury was killing the region's plankton, fish, shellfish, cats, dogs, birds, pigs, and humans. Despite the availability and relative ease of the technology for treatment of wastewater, it still continued to release this untreated wastewater into Minamata Bay for another 10 years until 1966.

From 1956, Japan was aware of the hazards of eating fish from areas around Minamata Bay. However fishing was never officially banned in the bay. Epidemiological studies were not carried out on the approximately 200,000 people who ate fish from the Minamata Bay area during the peak of the pollution. Chisso was never ordered to shut down its facility.

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[132] Harada M; Minamata disease: methylmercury poisoning in Japan caused by environmental pollution. Crit Rev Toxicol 25 (1): 1-24 (1995)

[133] Aileen Mioko Smith, January 1996

Instead, government action of that period was directed to interfering with scientific research efforts to ascertain the cause of Minamata Disease. These delays further exacerbated the effects of the pollution and could likely have lead to more cases of Minamata Disease.

As of 1996, over 14,000 individuals had applied for official designation as Minamata Disease victims[134]. The true number of victims is largely unknown. Since individuals had to apply on their own initiative, those that may have been unaware that they were suffering from Minamata Disease may have died of the disease. Others were too sick to apply for designation themselves. Many fishermen, concerned that their designation as victims would damage fish sales, would not apply for designation as victims. There is no way to account for spontaneous abortions.

The Struggle for Rightful Compensation

Minamata Disease has received worldwide recognition today due to the efforts and actions of victims and supporters relentlessly pressuring Chisso and the government to act responsibly and compensate the victims fairly. The struggle has taken its own toll. Anger and desperation have led to rallies and demonstrations, pitting groups against each other. Fishermen stormed the Chisso factory because their fish could not be sold. Chisso steadfastly refused to acknowledge that its acetaldehyde waste was the cause of Minamata Disease. Instead, the company offered very little compensation to victims and only on condition that they sign a contract barring them from pursuing further compensation in the event it may be proven at a future date that the wastewater from its plant was the cause of Minamata Disease.

Under threats by local governments that failure to accept the offer from Chisso would result in no compensation, on December 30,1959, victims unwillingly signed on and accepted the offer, marking the so-called resolution of the Minamata Disease problem.

The economy of Japan was flourishing at the beginning of the 1960s. But the Japanese government did nothing to regulate the other acetaldehyde plants of other corporations in Japan. As a result, methylmercury pollution increased to serious levels in many places. In 1965, a second major outbreak occurred in Niigata along the Agano River and was attributed to the Showa Denko Corporation's acetaldehyde plant located upstream.

In 1968, the government officially recognized Minamata Disease as a pollution disease caused by methylmercury from the wastewater of the Showa Denko's Kanose plant in Niigata and the Chisso Minamata plant in Kumamoto. This recognition resulted from extensive pressure by Niigata victims for failure of government to take preventive measures when the first outbreak had occurred in Minamata and then, only after the last acetaldehyde plant using the mercury catalyst method was shut down due to outmoded production technology.

[134] (This number signifies that at least ten per cent of the population that ate the contaminated fish fell victim to Minamata Disease.)

While Niigata victims were filing lawsuits against Showa Denko for compensation, Minamata victims were being encouraged to pursue Chisso's responsibility once again. Efforts to negotiate with Chisso directly failed, as the company cited the 1959 contract. The victims split into two groups, one that decided to try for additional compensation with the government as facilitator, and another to continue to seek direct negotiations between the victim and the polluter and make Chisso admit its responsibility for having caused Minamata Disease.

In the spring of 1973, after several years of continued pressure, broad international public support, legal action and marathon negotiations, Chisso was held legally responsible for having caused Minamata Disease. Chisso signed contracts committing to annual payments and medical expenses and compensation amounts that greatly exceeded the initial amounts awarded in the 1959 contract.

It has continued to be an uphill battle for victims. While Chisso received government assistance, claiming to be burdened by compensation payments, it became all the more difficult for victims to be so designated.

The government has sought to eliminate most Minamata victims from designation by comparing the medical effects of acute methyl mercury poisoning in an industrial worker setting (known as the “Hunter-Russell Syndrome”) with those suffering from Minamata Disease. This was done despite medical research that has indicated the very different illness patterns. The number of applicants for designation was reduced to one a year.

Lawsuits, court cases and appeals continued. Despite the power and resources of government, in half the court cases the government was found responsible for making Minamata Disease worse. The government appealed to a higher court, refusing to negotiate out-of-court settlement. In the meantime, after 8 to 16 years in court, many plaintiffs had died.

In 1995, the Japanese government issued its proposal, the Complete Solution to the “Non-Designated Patients Problem”, an all-time resolution to the Minamata problem.
In its proposal, the government would not accept official responsibility for Minamata Disease. The Prime Minister would issue only an apology. Victims would have to withdraw their lawsuits and their application for Minamata Disease designation.
Even if victims were to accept these conditions, they are not assured that they would qualify for the compensation money.

The above is a replay of the contract of 1959 with one change of players - from Chisso in 1959 to the government in 1995. After thirty- seven years, most of the victims accepted the plan reluctantly. One group of victims has held out - the Chisso Minamata Disease Kansai Lawsuit group.

To quote the head of the group, Natsuyoshi Iwamoto, now deceased,
"It's not an issue of money. What we're talking about is the government's responsibility for having abandoned and ignored us all these long years."

Those in the group who are still alive say, *"We will take this all the way to the Supreme Court bearing on our backs the sediments of all Minamata victims everywhere."*

Update on Minamata, October 2001

The following article, reporting on a conference on Minamata in Japan October 2001, appeared in The Guardian (London) October 16, 2001 Guardian Foreign Pages, Pg. 18

HEADLINE: Mercury poisoning of thousands confirmed: Thirty years on, the victims of Japan's worst case of industrial pollution are getting support from scientists and the courts - but not the state BYLINE: Jonathan Watts in Tokyo

Yesterday, more than 30 years later, researchers presented evidence that the mercury poisoning of Minamata bay in the 50s and 60s lasted longer, spread further and affected tens of thousands more people than previously believed. The study by doctors at Kumamoto University could cost the Japanese government billions of yen (millions of pounds) as thousands of claimants seek recognition as having Minamata Disease - the nerve disorder caused by eating seafood from the polluted bay or nearby waters. Symptoms of spasms, blurred vision and hearing loss were first recognized in the 50s when the ailment was called "itaiitabyo" (ouch ouch disease), but it was not until 1968 that the government blamed the nearby Chisso chemical corporation for pumping mercury waste into the bay. More than 900 victims died in agony.

Many babies in the area were born with knarled limbs. Thousands of victims were ostracized, first out of a mistaken fear that the disease might be contagious, and later, because their legal suits drew unwanted attention to the invisible pollution in this picturesque region.

In 1996, the government offered sufferers a modest settlement of about 1,500 pounds in damages from Chisso and 120 pounds a month in medical expenses from public funds. But since then it has only certified 2,264 victims, 1,435 of whom are already dead. Another 17,128 have applied for recognition.

According to the Kumamoto University research team, which is presenting its findings at a conference on mercury poisoning that started in Minamata yesterday, (October 15) at least another 20,000 people are likely to be eligible. By comparing levels of mercury and sensory disruption in residents on the far coast from Minamata with a control group from outside the area, the researchers found that harmful levels of pollution spread beyond Minamata Bay and lasted until 1970, 10 years longer than government estimates. They found that mercury damaged the central nervous system and impaired sight, hearing, smell, taste and touch when present at the level of just 10 parts per million in hair and umbilical cords. This is five times lower than the level recognized as harmful by the government. Campaigners for the rights of Minamata disease sufferers said the findings indicated that as many as 2m people might have eaten enough contaminated fish to suffer from such lesser, but still painful, side effects of mercury poisoning as constant headaches, loss of hearing and an inability to distinguish hot from cold.

The government, which has been accused of colluding with Chisso Corporation to cover up the environmental disaster, has never attempted to find out how many people were affected by Minamata disease. Instead, it has asked victims to come forward, which many are reluctant to do because they fear discrimination. "The problem is that the government has not launched a detailed epidemiological study," said Shigeo Ekino, the professor who led the research. "They are afraid of looking into the wider area."

In May, after Professor Ekino presented his initial findings, the Osaka high court ordered the government to recognize the claims of victims who had been refused certification. The government has appealed. Environment agency officials were unavailable for comment. Her legs numb and warped, Suemi Uemura, 66, is one of many Japanese people still waiting for full government recognition of Minamata disease, caused by the dumping of mercury in Minamata bay [*Entered October 16, 20*01].

Appendix C CWS Mercury Position Paper, September 1999
Environmental Non-Government Organizations (ENGOs)

Preamble

Under the Harmonization Accord and the Standards Sub-Agreement signed in January 1998, by the Canadian Council of Ministers of the Environment (CCME), excepting Quebec, governments have committed to develop and implement Canada-wide Standards (CWS) for substances that are of national concern to human health and/or the environment. At this stage, six substances have been selected as priorities for the development of Canada-wide Standards. Mercury is one of the priority substances. Development Committees (DC) composed of representatives from federal, provincial, territorial environmental and health departments have been established to guide the process and develop recommendations for standards. These recommendations are to be presented to the CCME for consideration at their November 29-30 1999 meeting.

Stakeholder participation and NGO representation are key components of the Harmonization Accord (Annex on Accountability and Public Participation). However, the mercury consultation process has been problematic from its initial stages. While several concerns with respect to NGO participation have been addressed with the CCME, the fact remains that we are few in numbers and the burden of representing the interests of the NGO community and the Canadian public is onerous.

The mercury standards process is utilizing a sectorial and differentiated approach in its attempts to set mercury emissions standards. The sectors selected as "candidates" include the major mercury emitters, namely, base metal smelters, waste incineration (including medical, municipal solid waste, and hazardous waste), coal-fired electrical power generators (EPG), and products containing mercury. The coal-fired electricity generating industry representatives are particularly obstreperous, advocating for delays in establishing targets and timelines, unwilling to advance reduction scenarios and are not forthcoming in supplying information. The ENGO representatives are concerned that the industry position is driving the process and that the DC proposals will reflect this bias – to the point where standards will be needlessly delayed and health and the environment unduly compromised.

In order to address this problem strategically, the ENGO representatives in the mercury consultation on September 13-14, 1999 in Toronto put forth their recommendations with respect to standards and overarching goals (see attached document, "ENGO Position Paper with respect to Mercury CWS). In just a few days, the position paper received endorsements by over 30 groups throughout Canada. This number continues to grow.

We are continuing to gather endorsements from NGO groups and other interested organizations and communities from across the country in time for the Minister's meeting (CCME) in November. We are asking that you review the document and sign on to the Position Paper (*contact information is provided at the end of the document*).

ENGO Position Paper - Mercury CWS and the Electric Power Generating Sector (September, 1999)

Goals and Principles

The ultimate or overarching goal and supporting principles that establish the context for setting standards on mercury emissions must encompass the following considerations:

- Mercury in its various forms is a Persistent Bioaccumulative Toxin (PBT), exhibiting neurotoxicity and fetotoxicity, posing risks to susceptible populations, in particular the developing fetus, children, women of child-bearing age, native populations, in addition to plants and wildlife;

- anthropogenic emissions of mercury have increased globally two- to five-fold over the last century;

- the contamination of fish from methylmercury, the most toxic form of mercury, and other pollutants have deprived wildlife, communities, and human population in general from a valuable and readily available food source;

- the impact of chronic exposure to long term “low levels” of mercury are unknown;

- uncertainty to date precludes the establishment of a threshold or safe level of exposure, if indeed such a level exists;

- viable options presently exist and can be further developed that would result in the prevention of use, generation and anthropogenic release of mercury to the environment; and

- international and binational agreements in which Canada is an active participant are being sought to reduce and eliminate anthropogenic sources of mercury;

Therefore, the ENGO community supports as overarching goal the elimination of the use, generation and release of anthropogenic sources of mercury to the environment in order to protect the most vulnerable populations and species of the ecosystem for the present and future generations.

(Note: The following apply in particular to the Electric Power Generating Sector)

The attainment of this goal would be realized through:

- Establishing targets and timelines that reduce mercury emissions from all domestic sources and sectors;
- Placing emphasis on pollution prevention at source;
- Pursuing initiatives that incorporate energy conservation, efficiency, and renewable resources as integral components to achieve standards, [for example, establishing "set-aside targets" that stipulate the per cent of energy to be gleaned from clean renewable resources];
- Switching to cleaner fuels (high efficiency natural gas), using heat recovery, cogeneration, where feasible;
- Pursuing multi-pollutant, integrated approach to mercury reduction;
- Improving monitoring techniques, accuracy and frequency of data collection including measurements of mercury emissions and coal analysis;
- Establishing an implementation and compliance protocol;
- Ensuring meaningful participation of the public.
- Mandatory reporting of mercury emissions by all sources; and
- **Ensuring that "Emissions Trading" is not a viable option for toxins such as mercury.**

Information gaps

At present, there is considerable debate as to accuracy and reliability of current stack emission concentrations and data. It is incumbent upon industry to provide the requisite information and to establish a uniform mechanism that accounts for the amount of mercury in coal and in emissions. Such information is to include:

- Coal analysis: accurate, routine reporting of the concentration of mercury in the coal feed;
- Mercury emissions data: routine monitoring and periodic (quarterly) reporting of stack emissions and mercury concentrations in the bottom ash and fly ash.

This data would lead to comparison of total input (of mercury in coal) to output (in ash).

It is expected that this data would be utilized to establish an accurate numeric emissions baseline or reference for setting reduction scenarios and/or caps **by December 2000.**

This data-gathering exercise does not preclude implementing interim percent emissions reduction targets using estimates of 1995 emissions as a baseline year. Lack of commitment to an active reduction strategy of mercury emissions at this point will signal unwillingness on the part of CCME to deal with an element that has been singled out as the pollutant of greatest public concern (by the U.S. E.P.A.).

Standards for Emissions Reduction (EPG Sector)

It is recommended that:

Emissions of mercury from coal-fired plants be reduced by 50% by 2005 and further reduced by 90% in year 2010, using 1995 as an interim baseline year.

The baseline year of 1995 would be replaced by a new baseline year of 2000 if and only if the emissions determined by the data-gathering exercise are found to be less in that year.

Furthermore;

- **All facilities** that emit mercury to the environment must comply with standards and reduction targets;
- Stack emissions are to be monitored routinely and reported quarterly;
- Based on continual input and improvement of data collection and reporting, the baseline year would be re-evaluated and altered if it would result in declining amounts of mercury released.
- Regional variations and strategies may be needed.
- The standard would undergo stakeholder-based review every 2-3 years.

Note: Endorsements were forwarded to the Canadian Environmental Network, The Ontairio Campaign, and to Anna Tilman (ENGO representative on the Mercury CWS – EPG and author of the position paper).

Endorsements of ENGO Position Paper

As of January 26, 2000, the following organizations have endorsed the "ENGO Position Paper with respect to Canada-wide Standards for Mercury":

Alberni Environment Coalition
Allergy and Environment Health Association, Nova Scotia
Brock Land Stewards
Campaign for Pesticide Reduction, New Brunswick
Canadian Association of Physicians for the Environment (CAPE)
Canadian Auto Workers (National)
CAW Local 1520
CAW Local 27
Canadian Environmental Defence Fund
Canadian Environmental Law Association (CELA)
Canadian Institute for Child Health
Canadian Institute for Environmental Law and Policy (CIELAP)
Canadian Lung Association (National Working Group on the Environment)
Canadian Parks and Wilderness Society (CPAWS) – Edmonton Chapter
Canadian Public Health Association
Canadian Union of Public Employees (Local 79)
Canadians for Responsible Northern Development
Centre for International Studies
Centre for Longterm Environmental Action in Newfoundland & Labrador
Citizen's Environmental Alliance of Southwestern Ontario [135]
Citizens for Renewable Energy
Citizens' Mining Council of NFLD, Inc.
Clean North
Clearing House Group
Coalition on the Niagara Escarpment
Comite de Protection de la Sante et Environnment, Gaspe
Comite de Vigilance Environnementale de l'Est de Montreal
Conservation Council of New Brunswick (CCNB)
David Suzuki Foundation
Deninu Kue First Nation
Earth Action
Echo (Ecological Choices), Lakehead University, Thunder Bay, Ontario
EcoCouncil of the Peterborough Area
ECO PEI
Ecology Action Centre, Nova Scotia
Edmonton Friends of the North
Environmental Mining Council (BC)
Environmental Youth Alliance, BC
Falls Brook Centre

[135] Advocating zero discharge

Federation of Ontario Cottagers' Association (FOCA)
Forest Protection Allies
Friends of Christmas Mountain
Friends of Red Hill Valley
Friends of Star Lake
Friends of the Earth (El Salvador)
Friends of the Environment
Friends of the Escarpment
Friends of the Rouge Watershed
Georgian Bay Association
Global Resource Centre (Windsor)
Grand Manan Whale and Seabird Research Centre
Great Lakes United
Green Alternative Institute of Alberta
Green Campus Society, Saskatchewan
Greenplanet Social Justice and Ecological Network [136]
Humber Environment Action Group (NFLD)
Humber Heritage Committee (Ontario)
Innu Nation (Labrador)
In Terra Action
Interchurch Uranium Committee (Educational Co-operative)
International Institute of Concern for Public Health
Kahnawake Environment
Kivalliq Inuit Association
Landcare
Le Parliament des Enfants Inc., Montreal
Mining Watch. Canada
Multimedias Inc.
Nature Saskatchewan
New Brunswick Lung Association
Northwatch
Ontario Public Interest Research Group (OPIRG - McMaster)
Ontario Lung Association
Ontario Public Service Employees Union Local 560 (Seneca College Academic Unit)
Ontario Toxic Waste Research Coalition
Pembina Institute for Appropriate Development
Peterborough EcoCouncil
Pictou Harbour Environmental Protection
Poetical Asylum
Pollution Probe
Prairie Acid Rain Coalition (PARC)
Prince Albert Earth Advocates
Reach for Unbleached (RFU)
Richmond Hill Naturalists
Rural Action on Garbage and the Environment

[136] Advocating zero discharge

Safe Sewage Committee (Toronto)
Salvadorian Centre for Appropriate Technology
Saskatchewan Environmental Society (SES) [137]
Save the Oak Ridges Moraine (STORM)
Save the Rouge Valley System (SRVS)
Say NO to American Garbage Group
Sierra Club of BC
Sierra Club of Canada
Sierra Youth Coalition (SYC)
Societe pour vaincre la pollution (SVP)
Society for Promoting Environmental Conservation (SPEC)
STOP, Montreal
Sustainability Project
The OntAIRio Campaign
Thompson Institute for Environmental Studies
Thompson Watershed Coalition
Toronto Bay Initiative
Toronto Environment Alliance (TEA) [138]
Toronto Public Health [139]
Toxic Watch Society of Alberta
Uxbridge Conservation Association
Warwick Watford Landfill Committee
Western Canada Wilderness Committee – Alberta
Wild Circle
Windsor & District Labour Council. Environment Committee
Windsor Women Working With Immigrant Women
Women's Action and Support Group (RIOT Grrl, Brampton)
Women's Network on Health and the Environment (WNH&E)
York Centre for Applied Sustainability, York University

[137] SES supports the specific recommendations for the electric power generating sector
[138] TEA believes that coal should be phased out where appropriate
[139] Toronto Public Health has submitted consistent position in writing to the Development Committee for mercury CWS

CANADA-WIDE STANDARDS – MEDIA BACKGROUNDER (November, 1999)

- Mercury is a potent and indestructible toxin that, even in small amounts, can have devastating effects on humans and wildlife that eat fish from contaminated waterways. Mercury can cause adverse and irreversible developmental disorders as well as brain, lung and kidney damage. Prenatal life (the embryo and fetus) is particularly sensitive to the toxic effects of mercury. Altered behaviour, reduced intellectual abilities and motor skills have been observed in children exposed to low levels of mercury. As a result, pregnant women, women of childbearing age, children, and communities that rely on fish and wildlife as a staple diet are most vulnerable to the effects of mercury.

- From the East coast of Canada to the Arctic, to Baffin Island and Hudson Bay and the Great Lakes, mercury levels are rising and effects are being felt in freshwater and marine fish and loons, otter and eagles.

- Levels of mercury in the environment have increased by a factor of two to five since pre-industrial times. As much as 70% of the mercury emitted into the atmosphere each year is attributable to industrial processes and sources such as such as incinerators, coal-fired plants, and smelters, according to studies by the Commission for Environmental Cooperation (CEC) and others. Even if all this activity would cease today, it would take at least 50 years before the fish would be safe to eat.

- It takes a mere 1/70th of a teaspoon, or about one gram of mercury to contaminate a small [25-acre] lake to the point where fish may be unsafe to eat. In Ontario, 99% of current fish advisories in inland waters are due to mercury. Every one of the Great Lakes has fish consumption advisories due to mercury as well as other contaminants.

- In the Great Lakes region, coal combustion is a major source of mercury emissions. The Electric Power Research Institute and Minnesota Pollution Control Agency have estimated that as much as 10% of the mercury released is deposited within 100 km of a power plant, 50% within 1000 km and the rest is transported vast distances. And though it may not be possible to determine the specific lake or stream that is impacted by one particular power plant's mercury emissions, there is no doubt that the mercury being released into the air is finding its way into water bodies and is contaminating the fish. In fact, recent reports from the National Wildlife Federation in the US indicate that levels in mercury in rain around the Great Lakes region are far exceeding levels deemed safe for human health and wildlife.

- Ontario Power Generation [OPG] has estimated that, in 1998, its coal plants emitted as much as 600 kilograms (that is 600,000 grams). This figure, considered to be a conservative estimate, represents about a 25% increase in mercury emissions from estimates of 480 kilograms in1995. (**Other estimates indicate a near doubling of mercury emissions over a three-year period.**)

- During this same time period, other mercury sources under the Canada-wide Standards study, such as smelters and incinerators, have realized reductions in mercury emissions

in the order of 40 to 90% respectively. (Senes Report, 1999 and Mercury Workshop, September, 1999)

- The picture looks gloomier, particularly in Ontario, with deregulation of the electrical industry coming into play in the next year. For just as the use of coal-based power, in particular from dirty coal-fired plants has increased south of the border since deregulation, a similar trend is more than likely in Ontario without government action and standards in place. While the use of coal, the dirtiest and cheapest source of power, may be beneficial to some of the biggest power distributors in the world, it hardly serves the interests and well-being of the health and environment of Ontarians.

- The Canadian Council of Ministers of Environment (CCME) is meeting near Calgary November 29, 1999 and has received recommendations from government representatives on setting specific standards for a number of pollutants deemed of national concern. One of these substances is mercury. It is now apparent, that despite the specter of consultations and deliberations over the last year, the recommendations do not contain a standard or reduction scenario for coal-fired power plants, only further delays. Human health and the environment are once more being compromised in order to "not negatively impact upon Canadian competitiveness and not disadvantage the industry." This is code for do nothing and act only if necessary.

- This industry has said "no standard" and government bureaucrats are saying "no standard". The intransigence of industry is overriding the well-being of Canadians. Interestingly enough, other major industries under study will be subject to standards that set out targets and timelines. The runaway electric power generators with coal-fired plants are being given free rein to continue to pollute and in increasing amounts.

- Representatives of non-government organizations in Canada are appealing to the Canadian Council of Ministers of the Environment to set standards now for coal-fired plants. We have developed a position paper that places at its primacy the protection of the most sensitive people and that sets out targets and goals to achieve reductions in mercury emissions from coal-fired plants. To date, more than 100 organizations have endorsed this document from coast to coast to coast. They include Health and Environment groups, First Nations, Labour and Social Justice Organizations

- In a letter endorsing the position paper, Chief Don Balsillie {Maurice Boucher} of the Deninu Kue First Nation, Fort Resolution, NT wrote, "*We are very concerned with the increasing levels of mercury in our fragile Northern Ecosystem. With the increase of the burning of hydrocarbons, including coal-fired generators, more mercury, we believe, is being released into the atmosphere. A large portion of our diet is vulnerable to this mercury exposure. We need to seriously look at reducing emissions in any way possible*."

Appendix D

RECOMMENDATIONS FOR

CANADA-WIDE STANDARDS FOR MERCURY

Electric Power Generation Sector

This document sets out strategies recommended for adoption by the Canadian Council of Ministers of the Environment (CCME) of Canada-wide Standards for mercury emissions from the Electric Power Generation Sector (EPG). It is specifically directed toward setting national standards that would result in significant reductions of mercury emissions from coal-fired plants in Canada. It includes background and rationale for the need for timely action to formalize standards in addition to strategic considerations for specific timelines and targets, reporting and review.

This document has been prepared for the Multi-Stakeholder Advisory Group (MAG) and the Development Committee (DC) of the Canada-wide Standards Mercury in recognition of Canada's international obligations and commitments to reduce anthropogenic emissions of mercury and in the interests of furthering the process and achieving timely and tangible results with no further delays.

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Canada-wide Standards, Mercury –Electric Power Generating Sector

March 2002

Recommendations for Canada-wide Standards: Mercury - Electric Power Generating Sector

A: Canada Wide Standards (CWS) for Mercury - Background

Under the Harmonization Accord and the Standards Sub-Agreement, the Canadian Council of Ministers of the Environment (CCME) has committed to developing and implementing Canada-wide Standards (CWS) for a number of substances that are of national concern to human health and/or the environment. Mercury has been selected as one of the priority substances. Stakeholder participation and NGO representation are key components of the Accord.

The CWS process for mercury has focused on atmospheric releases from designated sectors that account for most of such releases. These sectors include base metal smelters, waste incineration (including medical, municipal solid waste, and hazardous waste), coal-fired electrical power generators (EPG), and products containing mercury. To date, CWSs have been endorsed for smelters and incinerators[140].

B: Mercury – The Need for Action

Mercury in its various forms is an extremely toxic substance, a known neurotoxin and fetotoxin, posing a direct threat to human health and wildlife. As an element, it is both indestructible and persistent. Exposure to mercury has been documented to cause serious neurological and developmental damage that includes loss of sensory and cognitive ability, delayed mental and motor development (walking, talking, hearing and writing), learning disabilities, cerebral palsy, tremors, behavioural changes, reproductive difficulties, birth defects, kidney disease, and death. Recent studies of the toxicological effects of methylmercury in the United States indicate that at least 60 000 babies may be born each year in United States with neurological problems because of in utero exposure to methylmercury. Other estimates suggest the number of babies at risk may be in the order of 375 000. [141]

Symptoms of chronic or “low level” exposure of mercury over a long period of time are subtler. Since symptoms of mercury poisoning may not appear until after a latency period ranging from several weeks to months or even years after exposure, there is a likelihood of misdiagnosis, that is, failure to attribute mercury exposure as a cause of such symptoms. This is further complicated by the non-specific nature of many of these symptoms as well as the possibility of synergistic effects of exposure to mercury in addition to other toxic substances such as lead and PCBs (polychlorinated biphenyls).

Worldwide atmospheric levels of mercury have increased dramatically over the last 100 years or so, primarily as a result of anthropogenic emissions from industrial processes such as smelters, incinerators, coal-fired electric power plants and other facilities that use or

[140] CCME Canada-wide Standards for Mercury documents.

[141] Toxicological Effects of Methylmercury – National Research Council of NAS, July 2000 placed the number of babies at risk at lest 60 000. The U.S. Centers for Disease Control and Prevention (CDC) has published a recent study (March 2001) indicating that the number may be in the order of 375000 babies at risk.

burn substances containing mercury. The widespread use of mercury in numerous products, for example, florescent tubes, batteries, fungicides, electric switches, thermostats, thermometers and dental amalgam and their ultimate disposal further contribute to the mercury pool. Anthropogenic sources of mercury contribute to at least 70% of the estimated 5000 tonnes of mercury emitted annually to the atmosphere.

Most of the mercury emitted into the atmosphere is transformed into inorganic mercury, a highly soluble form of mercury. Through precipitation, inorganic mercury eventually drifts back to earth where it accumulates in the soil and waterways. Mercury can also be transported by wind patterns for thousands of kilometers and deposited far away from its origin. Microbial organisms in water or soil transform mercury into an organic form, methylmercury, a form readily absorbed by tiny living organisms, plankton. As larger aquatic organisms feed on the plankton, methylmercury concentrates in their tissues. Methylmercury bioaccumulates so efficiently in the aquatic food chain that predator fish at the top of the food chain have concentrations millions of times higher than levels found in surrounding waters.

Methylmercury is the most toxic form of mercury to living organisms. It readily crosses the placenta, targeting the developing fetal brain and central nervous system. The most common exposure route for humans and wildlife is through consumption of fish contaminated with methylmercury. At greatest risk to the effects of mercury contamination are women of childbearing age, pregnant women and their fetuses, children, and populations whose diet is dependent on fish as a traditional food source.

Concentrations of methylmercury found in many fish today, particularly the top predators, have reached a level where consumption of fish poses threats to human health. One gram of mercury, (the amount contained in a household thermometer), suffices to contaminate thousands of fish. In Canada's North, where native populations consume fish and other traditional foods year round, many individuals are accumulating dangerous levels of mercury and neurological symptoms of mercury poisoning have been reported [142].

The prevalence of mercury contamination in many lakes and rivers has triggered the need to set guidelines for fish consumption directed to protect the most vulnerable populations. Advisories range from an outright avoidance of fish consumption to restrictions in amounts and frequency of consumption based on the particular water body, fish species and size. For the most part, advisories are more restrictive for children and women of child-bearing age. Advisories on fish consumption of fish species from individual water bodies are in place in BC, Alberta, Manitoba, Saskatchewan, Ontario and Quebec. More than 90% of these advisories are due to excessive mercury contamination. Province-wide advisories are in effect in New Brunswick and Nova Scotia. To date, in the USA, 40 states and one territory are issuing similar fish consumption advisories [143].

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[142] 45-75% of Inuit and Cree sampled in the eastern Canadian Arctic have blood mercury levels above 20 micrograms/litre, the level set by the World Health Organization (WHO) as the upper limit of "normal mercury in human blood" levels. AMAP assessment report, Arctic Pollution Issues, 1998

[143] In July 2000, the U.S. National Academy of Sciences confirmed the EPA's reference dose for methylmercury of 0.1 micrograms per kilograms bodyweight per day, – the amount of methylmercury to which an individual can be exposed without adverse health consequences setting the stage for regulation of the coal fired electricity sector.

The accumulation of mercury in fish populations has far-reaching effects on wildlife at the high end of the food chain. Predatory mammals (panthers), marine mammals (whales and seals), and predatory birds (hawks and eagles) are most at risk. Mercury damages their livers, kidneys, most particularly, the central nervous system of these animals with the most devastating effects in embryos and the young. Mercury is the likely cause of reproductive failure among loons, eagles, mink, turtles, river otters, and other wildlife.

Mercury pollution and the consequent contamination of fish have significant implications for the human and wildlife food chain worldwide. A food source essential for the survival of wildlife and highly beneficial to human health is endangered, as fish have become the "canaries in a coal mine". Even if all new mercury releases would cease today, the mercury accumulated in soil would continue to be released through runoff into lakes for years, perhaps even centuries. It would take several decades before the fish would be safe to eat. No toxic metal is more insidious.

C. Canada-wide Standards (CWS) for Mercury - Electric Power Generating Sector

The CWS for the electric power-generating sector is due to be presented to ministers by the spring of 2002. While the future direction of the CWS process is unclear, it is possible that other sectors may be chosen for a standard-setting exercise. It is paramount that the process has regard first and foremost for prevention of releases of mercury and not risk becoming an exercise primarily directed to technological solutions via pollution control.

The paucity of information and the steadfast reticence of the utilities to provide essential information and data along with the apparent lack of willingness to move forward on this issue continue to be obstacles in the CWS process of setting standards since its onset more than two years ago. Furthermore, the process has been severely compromised with emerging proposals for new and expanded coal-fired plants, despite assurances from the industry that "no new plants would be built in the foreseeable future" and that a new source performance standard was unnecessary [144]. However, these recent developments reaffirm the need for such standards and the need to include mercury in the suite of substances for which performance standards would be established for new facilities.

D: Cumulative Impact of Emissions

Coal-fired plants are a major and growing contributor to the levels of mercury emissions in Canada. In 1999 alone, these facilities emitted approximately 2500 kilograms, representing about 39 per cent of the national atmospheric emissions for that year from major sources. Focusing on yearly emissions masks a highly significant property of mercury – its persistency. A more realistic and disturbing depiction of the loading of mercury into the environment by these facilities would result if cumulative emissions of mercury from these facilities were to be accounted for over the lifetime of their operation. When such cumulative impacts are considered, the total emissions over a twenty-year period from this sector are in the order of 50-60 tonnes [145].

[144] Interview Report with MAG Members, prepared by Raymond Vlies, July, 1999
[145] Refer to Appendix A in this document for a graphical interpretation of the concept of cumulative emissions.

E: Policy

Domestic Obligations and Commitments

Under the Canadian Environment Protection Act, (CEPA), mercury is designated as Track II substance, requiring life cycle management to prevent or minimize its release into the environment. The National Pollutant Release Inventory (NPRI) has been modified to require mandatory reporting of releases and transfers for facilities manufacturing, processing and otherwise using more than 5 kilograms of mercury annually as of the reporting year 2000.

The United States Environment Protection Agency (US EPA) will be regulating mercury emissions from coal-fired plants, the largest source of such emissions in the United States. The draft regulation is due 2003 and the final rule by 2004[146], with compliance expected by all units by 2007. ***Posting of mercury emissions from every coal-fired plant in the country is required along with detailed information on coal.*** Furthermore, US law will require other mercury sources to report their emissions of mercury and to strengthen regulatory restrictions to reduce the total human-caused mercury emissions nationwide by 50% from 1990 levels by 2006.

International Commitments

Concern regarding the large increase in global levels of mercury by two to five times over the past century and its implications for human health and the environment have led to a number of actions on a national and international scale. Canada has assumed obligations and commitments to reduce mercury emissions in the following agreements:

- The 1997 Great Lakes Binational Toxics Strategy (BNS), an agreement between Canada and United States[147], establishes a process to work toward ***virtual elimination*** [148] of specific persistent bioaccumulative toxic substances, including mercury, from the Great Lakes Basin. The Canadian goal was to seek a 90% reduction in the use, generation, or release of mercury by the year 2000 in the Great Lakes Basin. The US goal sought a 50% reduction by the year 2006 for all land-use based sources.

- The Mercury Action Plan adopted in 1998 by the Eastern Canadian Provinces and New England Governors states as its goal the virtual elimination of anthropogenic mercury in the region. The Plan calls for regional reductions in mercury emissions from identified sources that would achieve a 75% reduction in emissions by 2003. In addition, the plan incorporates monitoring, research, reporting, education and recycling programs.

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[146] The decision to regulate mercury emissions from coal-fired plants was announced December 2000. The EPA will issue its final rule by 2004 under section 112 of the Clean Air Act.

[147] The Strategy is in keeping with the objectives of the 1987 Great Lakes Water Quality Agreement (GLWQA).

[148] **Virtual elimination** as articulated by the International Joint Commission refers to **use, generation and release** of such substances by encouraging and implementing strategies consistent with the philosophy of zero discharge.

- The1998 UN ECE Long-Range Transboundary Air Pollution Heavy Metals Protocol relating to mercury, cadmium and lead, signed and ratified by Canada, and legally binding, is seeking 50% reduction from 1990 emission levels 8 years from ratification and the use of Best Available Techniques (BAT). At its 21st session (February 5-9, 2001), the Governing Council (GC) of the United Nations Environment Programme (UNEP) agreed to the undertaking of a global assessment of mercury and its compounds, including any relevant options for international action. The report and recommendations will be considered at its 22nd session in 2003.

- The Commission for Environmental Cooperation North American Regional Action Plan for Mercury was signed by Canada June 2000. It has established as its goal the reduction of mercury to approach natural levels and fluxes in certain environmental media, seeking a 50% reduction in mercury emissions by 2006.

F: Recommendations and Rationale for CWS - Mercury

a) Overarching Goal

An "overarching" long-term goal that addresses anthropogenic mercury emissions in Canada sets the context for a goal specifically for mercury emissions from coal-fired plants in Canada. The following text is submitted as the recommended overarching goal.

Whereas mercury in its various forms is a Persistent Bioaccumulative Toxin (PBT), exhibiting neurotoxicity and fetotoxicity, posing risks to susceptible populations, in particular the developing fetus, children, women of child-bearing age, native populations, in addition to plants, fish and wildlife;

Whereas mercury is designated as a Track 1I substance under CEPA requiring life cycle management to prevent or minimize its release into the environment;

Whereas the protection of human health and the environment is the underlying driver and affirmed rationale for setting CWS standards for mercury;

Whereas CWS standards are to result in significant reductions in emissions of mercury;

Whereas atmospheric mercury emissions from coal-fired plants are a very significant source of such emissions in Canada and have the potential to increase with expansion of such facilities; and

Whereas Canada is an active participant in international and binational agreements that seek to address significant reductions and elimination of anthropogenic sources of mercury; therefore,

The overarching goal is to eliminate the use, generation and release of anthropogenic sources of mercury to the environment in order protect the most vulnerable populations and species of the ecosystem for the present and future generations.

b) CWS Mercury for Coal -Fired Plants – The Objective

Given that mercury is a highly toxic substance and that the protection of human health and the environment is the underlying driver for setting Canada-wide Standards, and in keeping with the Precautionary Principle as set out as guidance in the CWS subagreement, the standard for atmospheric mercury emissions from the Electric Power Generating Sector and the associated targets and timelines must be of sufficient rigor in order to conform with the CWS objective of achieving significant reductions in mercury emissions in a timely fashion.

In consideration of the above, a national objective must establish the desired level of reduction of mercury emissions by a specified date. This objective should be expressed as percent reduction in emissions relative to emissions in a set baseline year and would be equivalent to a cap on mercury emissions.

Therefore the objective of the CWS standard recommended for the Electric Power Generating Sector is to seek at least 90% reduction in atmospheric emissions of mercury from all coal-fired plants in Canada by the year 2010, relative to baseline year 1999. This percent reduction is deemed to be equivalent to a "cap" on total atmospheric emissions of mercury from all such facilities of 250 kg for 2010.

This objective is to be accomplished by setting appropriate standards in terms of mercury emission rates for both new and existing facilities.

c) Features of The Standard

The following points lay out features to be considered in establishing a national standard such as targets and timelines, interim standard, a reporting and monitoring protocol, implementation plans and a review process, all of which lie under the purview of multi-stakeholder involvement.

i) The criteria and definition for the designation of new, modified and expanded plants need to be clarified. The objective of 90% reduction in mercury emissions must incorporate all and any such additional facilities that may come on line.

ii) An interim target of 50% reduction is to be achieved by 2007 and is to apply to all jurisdictions. This interim target is to incorporate any additions and/or modifications to the fleet of coal plants.

iii) The standards, targets and timelines include the total fleet of coal-fired plants, that is, all existing, new, modified and/or expanded facilities in operation.

iv) **Standards, targets and timelines are to be applied to each facility in every jurisdiction.** Each facility is required to meet the specified targets of a mercury emissions limit and rate within the established timelines. It is recognized that boilers within a given facility may have different operating

conditions and controls. Those units with higher emissions rates and few if any controls need to be addressed as priority actions.

v) Maximum permissible mercury emission rates for new modified and/or expanded coal plants must be set at the most stringent level using the Best Available Techniques (BAT) and must apply the year such plants commence operation. **Standards for existing facilities must at minimum be as stringent as the target set for 2010 for new plants.**

vi) The recommended baseline year for reference is 1999. The data for this year is the most current and likely the most appropriate to reflect the emissions to date. While estimates range anywhere from about 2000 kg – 2600 kg, it is recommended that the base value of 2500 kg be chosen, as the most probable and conservative estimate of the 1999 emissions. The baseline will be subject to review, as more information is made available. However, the base value should remain constant and not exceed 2500 kg.

vii) The recommended form of the standard is an emissions rate, expressed as the ratio of the amount of mercury emitted to generation, or energy output expressed in mg/MWh.

viii) Preference is to have a uniform standard across the board for all facilities to comply with both the interim 50% reduction and the goal of 90% reduction. Another option would lean toward a range of standards according to coal type or blends. While this may be useful as an interim measure, it does not apply to new plants and introduces a level of complexity that is controversial. On the other hand, the application of a uniform standard regardless of coal type would be an incentive to reduce mercury content in coal.

ix) A standard cannot be based on "capture rate". This can be misleading in that it builds upon a presumed amount of capture that is questionable. Furthermore, it is confusing to set a percent capture and translate it into a percent reduction – two different values. Nor does this concept address many salient factors such as mercury levels in coal, increases in generation or new and modified facilities [149].

x) The annual mercury emissions and generation from each facility must be reported to ensure that the cap is not exceeded [150]. [The possibility of increases in generation beyond 1999 resulting in a corresponding increase in mercury emissions must be considered and factored into the value of the standard.]

[149] Appendix B of this recommendation document gives an in-depth explanation of "capture rate".
[150] The amount of mercury released through manufacturing, processing and otherwise used) greater than 5 kg must be reported on the NPRI.

xi) A **mandatory annual reporting and monitoring protocol** consistent for and applicable to all facilities in all jurisdictions is to be established. Essential components include (but is not be limited to) the following:

- Coal type, blend and source
- Amount of coal burned
- Heat content
- Mercury concentration in coal (ppm) and total mercury (kg)
- Sulphur and chlorine content
- Total annual amount of mercury emitted (kg)
- The speciated amounts of mercury emitted (elemental, ionic, particulate)
- Amount of mercury "captured"(fly ash) and its fate – use, landfill, etc.
- Mass balance Analysis of Mercury
- Net Generation
- Mercury Emission Rate (mg/MWh)
- Capacity Factor
- Pollution controls specifically for mercury as well as for other pollutants.

xii) No exemptions are to be allowed for facilities emitting < 5 kg annually. It is important to account for the total amount of mercury being released from anthropogenic sources. Not only is there no known threshold for mercury effects, one must consider the impacts on sensitive populations as well as the cumulative adverse effects from multiple facilities or sources in a region must be considered.

xiii) **"Emissions Trading" is not a viable mechanism for the elimination of persistent bioaccumulative toxins such as mercury.** Mercury is an element and does not break down. Once released, it adds to the global pool. Emissions Trading cannot address either local deposition or global loading issues.

xiv) All jurisdictional implementation plans and compliance strategies are to be in place by year 2003 and reviewed in multi-stakeholder fora. Jurisdictions that regulate thermal electric facilities are accountable for specifying and achieving reduction targets that are consistent with the CWS objective.

xv) **A pollution prevention (P2) strategy** is to be developed to include:

- Initiatives that incorporate energy conservation, efficiency, and renewable resources as integral components to achieve standards;
- Switching to cleaner fuels (high efficiency natural gas), heat recovery, cogeneration;
- Establishing of "set-aside targets" that would stipulate the per cent of energy to be gleaned from clean renewable resources, for example 10% by year 2010;

xvi) "Risk-benefit and cost-benefit analyses" must incorporate health and societal benefits as well as the ensuing avoided costs over the long-term. [Cost-benefit analyses have been leveled at operational and capital expenditures without taking into account the burden to the environment and human health.]

xvii) **Review of Standard:** A public review of the standards and implementation plans for new, proposed and existing facilities is to take place in 2005 in a multi-stakeholder forum. The thrust of the review must look for greater reductions in emissions with no backsliding. Specific components include:

- The effectiveness of the interim targets and timelines and progress to date;
- Emerging mercury pollution control technologies;
- Multi-pollutant, integrated approach to mercury reduction and co-benefits;
- Pollution prevention strategies;
- Efficiency of Coal-Fired Plants in generating electricity;
- Review of monitoring and reporting protocol in areas such as monitoring techniques, accuracy and frequency of data collection, measurements of mercury emissions and coal analysis and verification of data;
- Review and update of jurisdictional implementation plans;
- Review of existing fleet, for new, modified and/or expanded coal plants, and any further proposals;
- Review of New Source Performance Standards for Coal-fired Plants;
- Assessment of local, cumulative and long-range impacts of new, modified and existing coal plants;
- Progress report on Canada's international commitments on mercury.

xviii) Facilities are required to supply the appropriate information to enable a detailed analysis for the purposes of the reporting and monitoring protocol and the review. This information must be made publicly accessible.

G: Recommended Workplan and Schedule [151]

The following table summarizes targets, timelines and actions required to achieve the 90% reduction objective in atmospheric mercury emissions from coal-fired plants by 2010. Reductions are determined based on the 1999 mercury emissions of 2500 kg.

Schedule	Actions to be Achieved	Mercury Standard mg/MWh (emission rate)		Target – Objective Base year 1999: Emissions - 2500 kg (cap)	
		New Facilities	Existing Facilities	Total Mercury Emissions	Equivalent Per Cent Reduction
2002	Set national objective and emission rate standard to apply to: i) new facilities - compliance on start-up ii) existing facilities - compliance in 2010	**1.8**	**1.8**	**Objective:** **250 kg by 2010 (new and existing facilities)**	**90 % reduction by 2010**
	iii) Set 2007 interim standard to apply to facilities existing as of 1999		**< 10**	**Maximum 1250 kg**	**50 % reduction**
2003	Mandatory Reporting and Monitoring Protocol				
2003	Jurisdictional Implementation Plans in Place				
2005	Review of Standard				
2007	Conformance with interim standard			**1250 kg**	**50**
2010	Conformance for all facilities			**250 kg**	**90**

H: Conclusions

Unless sufficient progress is made toward a robust CWS for mercury air emissions from coal-fired plants by the spring of 2002, it is recommended that Environment Canada invoke appropriate regulation forthwith under CEPA to establish emission rates and limits from these facilities, both existing and new/and modified, that would result in 90% reduction in emissions in total by the year 2010, based on the 1999 mercury emission estimates of 2500 kilograms.

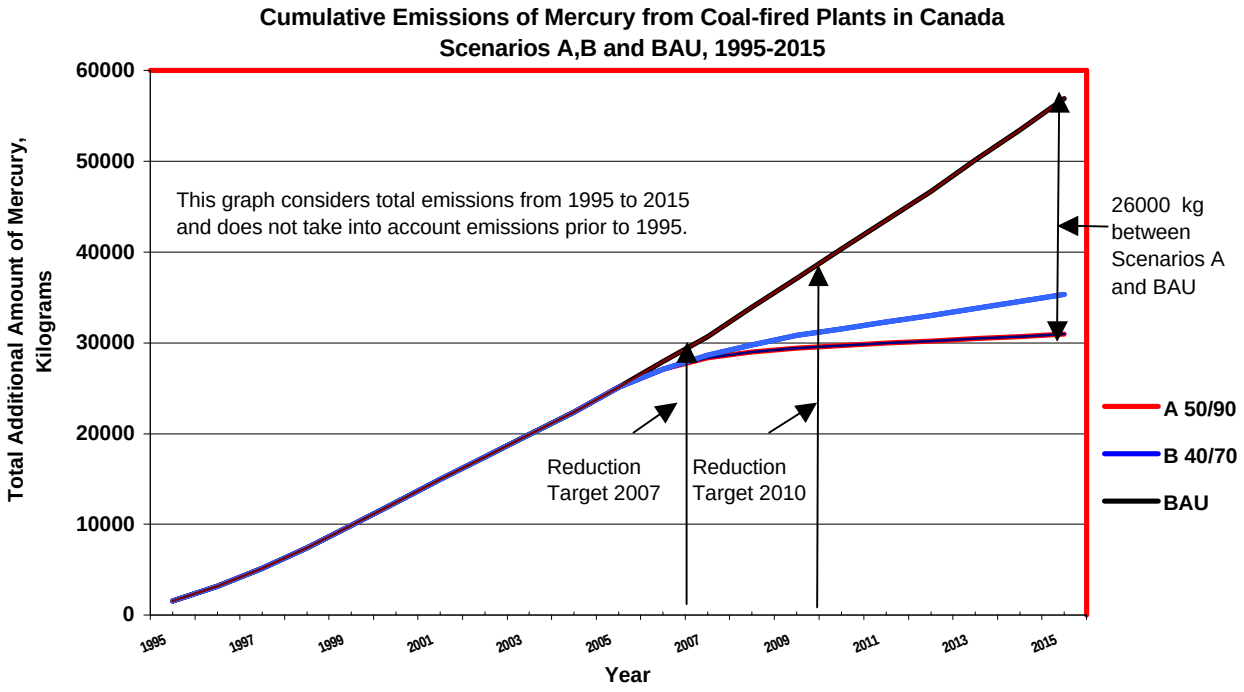
Furthermore, regulations would include requirements for the submission of appropriate information by these facilities as requested under Part F (xii) of this document.

[151] The emission rates estimated in the chart are based on estimates of current emissions and include a 20% safety margin to account for errors and potential increases in generation.

Appendix A:

Cumulative Impact of Emissions from Coal-fired Plants in Canada

The graph below illustrates the rise in cumulative emissions of mercury from existing coal-fired plants in Canada over the period from 1995-2015 under three scenarios: BAU - Business As Usual, that is, no reductions; “50/90” scenario, emission reductions of 50% by 2007 and 90% by 2010 (1999 base year); and “40/70” scenario, representing a 40% reduction by 2007 and 70% by 2010.



All three curves demonstrate the continual **increase** in the accumulated amount of mercury in the environment over time. It is only by making **significant** reductions in the annual emissions of mercury from these facilities within the next 7-10 years that the rate of accumulation of mercury emissions lessens (scenarios A and B).

The graph makes it all the more evident that undue delays in implementing a standard to significantly reduce mercury emissions prolong and exacerbate the mercury loading to the environment both locally and long-range.

Appendix B:

An Argument Against the Use of "Capture Rate"

It has been suggested at CWS workshops that "capture rate" could be used as a base for the CWS for mercury, that is, the percent of mercury in coal that is being removed or captured by air pollution control devices and hence not released to the air. For example, the objective would be stated in terms of a 65-70% "capture rate" that would in turn result in a 50% reduction in air emissions.

This is not a sound route for a number of reasons. It conveys a greater reduction, viz., 70%, than is actually realized. It is based on the assumption that about 30% of the mercury is currently being controlled or captured at the national level and not released to the air. This is not necessarily valid. In fact, based on information presented at CWS meetings, the percent "controlled" (capture "rate") is highly variable from province to province and ranges anywhere from 0 % (no capture) to about 45%. Furthermore, facility-specific capture rates are not been publicly available and to all intents and purposes are of questionable reliability.

The following chart is designed to assist in clarification and interpretation of the concept of "capture rate". The chart displays capture and emission rate scenarios using the 1999 atmospheric mercury emissions of 2500 kg and total mercury content in coal of 3600 kg.[152] It is important to understand that a 30% mercury capture rate means that 70% of the total mercury in coal is emitted into the atmosphere.

The chart portrays the likelihood of increased "capture" of mercury through pollution control devices. In addition, the potential of increased generation from these facilities (for example, 10% and 20%) is factored in with the implication that more coal would be burned and hence correspondingly more mercury released.

Mercury Capture Rate versus Percent Atmospheric Mercury Emission Reduction

Mercury Content in Coal (kg)	Mercury Captured (kg)	Mercury Emitted (kg)	Per Cent Captured %	Emission Reduction %
3600	1100	2500	30	0
3600	**1800**	**1800**	**50**	**28**
3600	2350	1250	65	50
3600	2850	750	80	70
3600	3350	250	93	90
4000	1500	2500	38	0
4000	2750	1250	69	50
4400	3150	1250	72	50

[152] The mercury-in-coal content figure of 3600 kg total was given at CWS meetings. However, this figure in itself is of questionable reliability since information on mercury content in coal is not readily or generally available.

Note that a 50% capture rate really signifies a reduction in atmospheric emissions of mercury of only 28%. In consideration of the likelihood of a large margin of error, at least 20%, one could question whether any real reduction in emissions would occur.

Summary of Issues:

By using capture (rate), the mercury content of coal becomes the baseline by default rather than the air emissions of mercury.

New or modified plants are not addressed by this approach. Any facility on the drawing board will not have a present capture or removal rate.

"Capture rate" combined with "emission reduction percent" result in two different numbers (expressed as percents) to indicate a level of reduction. This approach leads to a possible misrepresentation and misinterpretation of the standard. It is also not consistent with the approach taken for other CWS to date.

Different terminology is being used inappropriately to describe or explain the standard, such as removal, recovery, and control, capture "rate", "performance rate", and potentially another source of confusion.

This approach fails to consider the need to reduce mercury at the source through measures that can include the selection of a coal-type or blend with lower concentration levels of mercury, cleaner coal technology, fuel-switching, energy conservation and other alternatives. Capturing more mercury yet not attempting to reduce its input is no solution.

This approach does not factor in the energy efficiency in the use of coal as an energy source (presently about 30-35%) and the negative impact on efficiency by compounding pollution control devices.

To date, no facility - specific or province-specific data on capture or mercury-in-coal content has been made publicly available. Such information, if known, has been considered "confidential".

How does this approach fit into a multi-pollutant strategy?

In conclusion, a mercury capture rate is a confusing statistic that lacks scientific merit. A far sounder and simpler approach than a "capture rate" is a standard directed to address emission reductions from all facilities – new and existing. Thus the form of the standard should be mercury emission rates that apply to all facilities and that would result in meeting the objective of 90% reduction in atmospheric mercury emissions from coal-fired plants by 2010.

ENGO Presentation
CWS Mercury – Electric Power Generating Sector
June 4, 2001
Edmonton, Alberta

Topics

- **Introduction – Update and History on Process**
- **Data and Information Sharing**
- **Equity of Participants**
- **The Status – Taking Stock**
- **Responsibilities – Government, CCME and the DC for Mercury**
- **The National Scene – The Future of Coal**
  Looking mighty good and very cheap
- **Solutions**
- **Setting the Standards**
- **Goals and Principles**
- **Scenarios**
- **Discussion of Issues**
- **Presentation of Data**
- **Conclusions**

Responsibilities - Government, CCME and the DC for Mercury

Ministers of Environment are mandated to protect the environment. In the particular matter of CWS, it is expected that environment ministries and the DC:

- Set appropriate standards, targets and timelines to significantly reduce (eliminate) emissions of substances hazardous to human health and the environment;
- Develop pollution prevention strategies;
- Provide the necessary legislative tools, regulations and enforcement;
- Collect and disseminate information to the public;
- Consult with a broad array of stakeholders;
- Encourage and develop public awareness and education.

The National Scene - The Future of Coal

Looking mighty good and very cheap!

- Emissions of mercury from coal-fired facilities have been grossly underestimated, and we are far from sure as to just how much of this toxin is being emitted.
- The energy scene as a whole in Canada is not particularly encouraging, with no true national energy policy on the horizon. We echo the US in the need for oil and gas exploration and new energy facilities, in particular the good old new coal plants to address the energy-hungry nation of the US.
- Canada has been caught with no updated new source performance standards, other than a document gazetted in 1993[153]. The Canadian New Source Performance Standards of 1993 fails to mention mercury and allows for about 3 times the amount of NOX emissions as the US New Source Plant Standards permit.
- New coal plants **are** on the horizon – at this date 3 new plants in Alberta – as a planned to come into operation as Alberta's centennial celebration in 2005.
- Deregulation is the credo of the day. Where is the benefit analysis or certainty on deregulation? And what is the rush?
- The Kyoto Protocol is not the motivator, particularly with the shameful position that Canada and the US have taken.

[153] Thermal Power Generating Emissions – National Guidelines for New Stationary Sources, Department of the Environment, Extract Canada Gazette, Part 1, May 15, 1993

SOLUTIONS

i) Establish an overall national objective, for example percent reduction by a specified year or an absolute cap.

ii) Set a baseline, using the 1999 figures as the best available.

iii) **Standards are to be applied to each facility.**

iv) Each facility must meet the minimum targets of a mercury emissions limit within the established timelines. The form of the targets could be based on stack emissions expressed as the ratio of milligrams of mercury to energy output (mg/MWh) that can be converted to total annual amount of mercury.

v) Define new sources - Establish stringent new source standards.

vi) Establish a reporting and monitoring and data collection protocol.

vii) As part of the expected extensive review period of the "standard" in 2005, incorporate new technologies and multi-pollutant reduction benefits.

viii) Develop an in-depth pollution prevention strategy and energy strategy that earmarks a mandatory percentage of energy from renewable sources.

ix) "Cost-benefit analysis" must not be limited to an industry-driven approach that tends to look at upfront operational costs, rather than a long-range view that includes benefits and avoided costs as well as social costs and benefits.

Suggested Preamble: Goals and Principles

Whereas the protection of human health and the environment is the underlying driver and affirmed rationale for setting CWS standards for mercury;

Whereas CWS standards are to result in significant reductions in emissions of mercury;

Whereas mercury in its various forms is a Persistent Bioaccumulative Toxin (PBT), exhibiting neurotoxicity and fetotoxicity, posing risks to susceptible populations, in particular the developing fetus, children, women of child-bearing age, native populations, in addition to plants and wildlife;

Whereas mercury is designated as Track 1I substance under CEPA and thus requiring life cycle management to prevent or minimize its release into the environment;

Whereas the contamination of fish from methylmercury, the most toxic form of mercury, and other pollutants have deprived wildlife, communities, and human population in general from a valuable and readily available food source;

Whereas the impacts of chronic exposure to long term "low levels" of mercury are unknown;

Whereas uncertainty to date precludes the establishment of a threshold or safe level of exposure;

Whereas anthropogenic emissions of mercury have increased significantly over the past 100 years (globally two- to five-fold);

Whereas Canada is a party in international and binational agreements that seek to address significant reductions and elimination of anthropogenic sources of mercury;

Whereas the reliance coal as a cheap source of energy is detrimental to human health and the environment and viable options for clean energy exist and must be pursued; and

Whereas, the release of mercury from coal-fired plants has significantly increased in Canada over the past decade;

Accordingly, an appropriate standard must be set to address these concerns and achieve significant reductions in mercury emissions from coal-fired plants. The following recommendation it sets out national targets and timelines. The recommendation is presented in 4 parts, namely, Baseline year; Recommended Standard Scenario, Testing, Monitoring, and Reporting; and Review.

Recommended Standard Scenario for Existing Coal-fired Plants – Facility-Based:

Activity	Implementation Schedule	Mercury mg/MWH (stack emissions)			Per Cent Reduction		
Scenarios		A	B	C	A	B	C
Interim standard	2002						
Testing/ reporting	2003						
Review of Standards	2005						
	2007				50	45	40
	2008						
Compliance	2010				90	80	70

New Facilities

On no account must the introduction of new facilities result in non-compliance.

Discussion on Proposed Standards:

The suggested framework for standards and timelines must be of sufficient rigor to send a strong signal to realize large reductions.

Total Pollutant Loading

Form of Standard

- **Type of coal**
- **Local and Cumulative Impacts**

Testing, Monitoring and Reporting

Extensive Review

Review - 2005

A thorough review of the standard for both new and existing facilities would begin in 2004 with multi-stakeholder input and culminate in 2005. The thrust of the review must lead to greater reductions in emissions (no backsliding).

The review would consider but not be limited to the following:

- The effectiveness of the targets and timelines
- Pollution prevention strategies at source;
- Initiatives that incorporate energy conservation, efficiency, and renewable resources as integral components to achieve standards, [for example, establishing "set-aside targets" that stipulate the per cent of energy to be gleaned from clean renewable resources];
- Switching to cleaner fuels (high efficiency natural gas), using heat recovery, cogeneration, where feasible;
- Multi-pollutant, integrated approach to mercury reduction and co-benefits;
- Improvement of monitoring techniques, accuracy and frequency of data collection including measurements of mercury emissions and coal analysis;
- Establishing an implementation and compliance protocol;
- Mandatory reporting of mercury emissions by all sources; and
- Ensuring meaningful participation of stakeholders

"Emissions Trading" is not a viable option for toxins such as mercury.

NGO Presentation – Anna Tilman
CWS Mercury – Electric Power Generating Sector (EPG)
September 10, 2001
Fredericton, New Brunswick

Topics

Part A: Prerequisites for Setting Canada-wide Standards (CWS) Mercury - EPG

Terminology - Definitions

Information Sources

Updates on Proposals for New Coal-Fired Power Plants

Part B: Assignments - Data Collection and Verification

Part C: Recommended Strategy for CWS – Highlights

Preamble – The Need for Action

National and International Obligations – Catalysts for Action

Development of CWS for Mercury – Rationale

Summary of Recommendations for Standards

Schedule for Compliance

Part D: Reduction Scenarios

Part E: Cumulative Emissions

Part F: Outstanding Issues for MAG Members

Part G: Concluding Remarks

Part A: Prerequisites for Setting Canada-wide Standards (CWS) Mercury - EPG

Terminology:

Need for clear and consistent definitions and terminology
Uniformity in interpretation and use of terminology for all facilities

Form of Standard:

Emission rate - mg mercury emitted per MWh *generated* (mg/MWh)
[Note: Is g*eneration- gross OR net (delivered)?*]

Other Considerations–coal type, new versus existing plants

Clarification required for the following terms[154]:

Capacity

- Capability
- Net Capacity (available to grid)
- Baseload Capacity
- Net-In Service Capacity
- Gross Capacity
- Installed Capacity
- Maximum Continuous Rating (MCR)
- Generator Name Plate Capacity - Is this updated if modifications are made?
- Rated Capacity

Generation

- Net Generation
- Gross Generation
- Delivered Generation
- Maximum Gross Delivered Generation

Capacity Factor (CF)[155]: Ratio of (Gross) Generation/ Capacity (MCR), as Per Cent**.**

Changes in CF impact on the **amount of mercury** emitted, not on emission rate. For example, if the CF is increased from 50% to 70% (increase in generation), mercury emissions would increase by 40%, while the emission rate would remain constant.

Safety Margin: Critical for some facilities operating at a CF > 85%. [CFs currently range between 17% to 92%, with a median of about 75%.]

[154] For other related terms, refer to Excerpts from "Quick Glossary" and the Quick Glossary File attached.
[155] CEA Definition of CF: The ratio of the average load during some time period to rated capacity.

Information Sources

Facility Web Sites

- Web Sites need to be updated
- Conflicting information on terminology (for example, capacity and generation)
- Emphasis on coal as a low cost plentiful source of energy
- Scant (if any mention) of mercury or CWS
- Specific useful information is unavailable and/or inaccessible

Helpful Hints for Improvement of Web Sites

Suggestions for Inclusion:

- FAQs – Frequently Asked Questions
- FQAs – Frequent Questions Answered
- Update on Projects, for example
    - Ø Renewable Energy Strategies
    - Ø Energy Conservation
    - Ø Pollution Prevention
    - Ø Fuel Switching,
    - Ø Expansion, Modification, New Plants
- Specific Coal Information
- Pollution Controls - in place and planned for mercury capture
- Multi-Pollutant Reduction Strategies
- Links to Programs, Studies and Initiatives such as:
    - CCME and CWS – Mercury, PM and Ozone, MERS
    - Reporting sites – e.g., NPRI, others
    - Health and Environmental Impacts
- Mercury Reduction Programs and International Commitments and Involvement and Obligation of facilities
- Updates on topical conferences

Updates on Proposals for New Coal-Fired Power Plants (from Facility web-sites)

Company	Year	Capacity Megawatts	Location	Comments from Web-Site
Epcor – Phase 3	**2005**	**400**	**Genessee, AB (expansion)**	"Phase 3 Project to generate 450 MW (gross)" " Proposing to add a 490 gross/450MW net unit" "400 MW capacity addition to the Alberta grid"
Enmax and Fording	**2005**	**400**	**Brooks, AB (140 km S.E. of Calgary)**	Addition of 400 MW (net) plant) – to consume 44 million tonnes of coal over 35-year life. Proposed to be efficient at 43% (an increase in efficiency of 26% over existing coal-fired units in Alberta.
TransAlta	**2005**	**900**	**Keephills, AB (expansion)**	TransALTA Centennial Project - Two new units to be added (450MW each)
Other(s)? COGENTRIX?		**(2500)**		Unknown status

Further Comments:

Existing Capacity of Coal Plants in Canada: 17,200 MW

- **Proposals to date: > 1700 MW, - about 10% of current capacity**
  (excluding COGENTRIX and others)

Enmax and Fording:
The proposed Brooks plant is initially planned for one unit. However the plant's design will accommodate a second unit.
In 1992, Fording received approval in principle from the Alberta Government fore development of a surface coal mine and a **two-unit 800 MW** power station.

The web-site message: Coal is the fuel of choice for power generation – provides predictable assured supply of low-cost electricity – the Alberta Advantage.

What other proposals are coming forth?

Part B: Assignments – Data Collection and Verification (Industry, Governments, Others)

Assignment #1:

1. Clarify use of terminology with respect to the different nomenclatures for Capacity, Generation and Capacity Factor and their relationship to each other.
2. Update nameplate capacity to reflect the actual rating as necessary.
3. Scrutinize relevant documents for consistency in data and amend as necessary.

Assignment #2
(Refer to table "Coal-Fired Plants in Canada, Mercury Emissions Profile – 1999"):

Verify, correct and amend and supply missing data to columns:

- Facility (Boiler Units in Operation) and In-Service Dates
- Capacity (Net) in MW
- Delivered (Net) and Gross Generation
- Mercury Emissions (kilograms)
- Mercury in coal content (in kilograms)

Assignment #3 – Related Coal Information required for each facility:

- Type of Coal (lignite, sub-bituminous, bituminous, blend) and source location
- Amount of coal (Mg) used
- Mercury Content (concentration in coal in ppm as well as amount in kilograms)
- Per Cent mercury in fly ash captured and fate
- Heat Rate and Heat Value of Coal
- Efficiency of Coal as energy source for the generation of electricity (~ 30%)
- Processes for "cleaner coal", gasification
- Boiler Units in Operation, Year Commissioned, Retirement/Closures, Lifespan
- **Future Plans to replace coal by conversion, renewable resources**
- **Projections on Energy Demand**
- **Energy Conservation Initiatives**

Assignment #4 (Industry and CEA) - Revamping Web Sites:

- Update the homepage as well as other relevant sections
- Provide links in a user- friendly fashion
- Be informative on issues of the day
- Clarify terms (as in Assignment # 1, PART A)

Please submit work to: annatilman@sympatico.ca by:
November 1, 2001- Project # 1,2: December 1, 2001-Projects #3,4.

Grades may be assigned accordingly: A(Outstanding effort), B (Satisfactory), F (Unsatisfactory), INC (Incomplete), DNS (Did Not Submit).

Table: Coal-Fired Plants in Canada
Mercury Emissions Profile - 1999

Province (Utility)	Facility (Boiler Units)	In-Service Dates	Capacity		Delivered Generation	Capacity Factor [6]	Mercury Emissions[1]	Mercury Coal Content[2]	Mercury Emission Rate
Units		**Year(s)**	**MW**	**GWh/year**	**GWh/year**	**%**	**kg**	**kg**	**mg/MWh (net gen.)**
Nova Scotia									
NSPI	**Lingan (4)**	1979-84	600	5256	4200	80	**85**		20
	Point Aconi (1)	1994	165	1445	1080	75	**21**		19
	Point Tupper(1)	1973	150	1314	970	74	**22**		23
	Trenton (2)	1955-91	310	2716	2000	74	**43**		22
NS Total [3]			**1225**	**10731**	**8250**		**171**	**250**	
New Brunswick									
NB Power	**Belledune (1)**	1993	460	4030	2943	70	**50**		17
	Grand Lake (1)	1963	61	534	267	50	**97**		363
NB Total [4]			**521**	**4564**	**3210**		**147**	**150**	
Ontario									
OPG [5]	**Atikokan (1)**	1985	215	1883	1112	59	**68**	94	61
	Lakeview (4)	1962-69	1140	9986	3169	32	**87**	84	27
	Lambton (4)	1969-70	1975	17301	8937	52	**135**	257	15
	Nanticoke (8)	1973-78	3920	34339	18925	55	**260**	500	14
	Thunder Bay (2)	1981-82	310	2716	1611	59	**80**	122	50
Ontario Total			**7560**	**66226**	**33754**		**630**	**963**	
Manitoba									
MB Hydro	**Brandon (1)**		95	832	326	39	**6**	9	18
	Selkirk (2)		132	1156	199	17	**5**	6	25
Manitoba Total			**227**	**1988**	**525**		**11**	**15**	

Table: Coal-Fired Plants in Canada
Mercury Emissions Profile – 1999 (continued)

Province(Utility)	Facility(Boiler Units)	In-Service Dates	Capacity		Delivered Generation	Capacity Factor [6]	Mercury Emissions[1]	Mercury Coal Content[2]	Mercury Emission Rate
Units		**Year(s)**	**MW**	**GWh/year**	**GWh/year**	**%**	**kg**	**kg**	**mg/MWh (net gen.)**
Saskatchewan									
SK Power	**Boundary Dam (6)**	1959-78	875	7665	5820	76	**280**	320	48
	Poplar River (2)	1980-83	612	5361	4399	82	**300**	340	68
	Shand (1)	1992	300	2628	2325	88	**100**	125	43
Sask. Total			**1787**	**15654**	**12544**		**680**	**785**	
Alberta									
ATCO	**Battle River (3)**	1956-81	760	6658	4778	72	**172**		36
	HR Milner (1)	1973	150	1314	970	74	**5**		5
	Sheerness (2)	1986,90	760	6658	6062	91	**123**		20
Epcor	**Genessee (2)**	1989,94	820	7183	6588	92	**106**	106	16
TransAlta	**Keephills (2)**	1982,83	754	6605	5727	87	**98**	163	17
	Sundance (6)	1970-80	1987	17406	15192	87	**278**		18
	Wabamun (4)	1956-67	569	4984	3190	64	**79**	91	25
Alberta Total			**5800**	**50808**	**42507**		**861**	**1530**	
Grand Total			**17120**	**149971**	**100790**		**2500**	**3693**	

Notes:

[1] 1999 data from Senes Report 2001, tables on cost estimates, CWS - Mercury

[2] 1999 data on industry information to CWS, March 2000 workshop (coal concentration, ppm)

[3] Total generation delivered for Nova Scotia and New Brunswick value - 1997 estimate, no more information

[4] Estimate of generation delivered

[5] Source: Coal-Fired Electricity in Ontario, MOE, March 2001,

[6] Capacity Factor - Generation/Capacity

Part C: Recommended Strategy for CWS Mercury - EPG - Highlights[156]

The following document sets out a recommended strategy for adoption in exercising Canada's international obligations and commitments to implement standards to significantly reduce mercury emissions from coal-fired plants. It includes a preamble and rationale for timely action to formalize standards with strategic considerations for specific timelines and targets, reporting and review. This document has been prepared for the MAG and the DC in the interests of furthering the process and enabling timely and tangible results with no further delays.

Preamble

Mercury – The Need for Action

Health and Environmental Impacts

Increase in Mercury Emissions from Anthropogenic Sources, Coal-fired Plants

National and International Obligations – Catalysts for Action

CEPA and NPRI (National Pollutant Release Inventory)

US EPA - Draft regulation on mercury emissions from coal-fired plants is due 2003, the final rule by 2004 with compliance by all units by 2006[157].

Great Lakes Binational Toxics Strategy

Mercury Action Plan (Eastern Canadian Provinces and New England States)

The1998 UN ECE Long-Range Transboundary Air Pollution Heavy Metals Protocol relating to mercury, cadmium and lead, signed and ratified by Canada

North American Regional Action Plan for Mercury signed by Canada June 2000

Development of CWS for Mercury - Rationale

Given that mercury is a highly toxic substance and that the protection of human health and the environment is the underlying driver for setting Canada-wide Standards, and in keeping with the Precautionary Principle as set out as guidance in the CWS subagreement, targets and timelines for the Electric Power Generating Sector must be of sufficient rigor in order to conform with the CWS objective of achieving significant reductions in mercury emissions in a timely fashion.

[156] The full document is attached – CWS Mercury – Recommendations v1 September 2001

[157] The decision to regulate mercury emissions from coal-fired plants was announced December 2000. The EPA will issue its final rule by 2004 under section 112 of the Clean Air Act.

Summary of Recommendations for Standards

a) **The objective of the standard is to seek at least 90% reduction in emissions of mercury from coal-fired plants in Canada by the year 2010, relative to baseline year 1999, equivalent to emitting less than 250 kg of mercury by 2010 from these facilities.**

   An interim target of 50% reduction by 2007 is to apply to all jurisdictions.

   The preferred form of the standard is the emissions rate, mg/MWh - the ratio of the amount of mercury emitted to net generation.

b) **Standards, targets and timelines include the total fleet of coal-fired plants - all existing plants in operation, and any proposed new, modified and/or expanded facilities.**

c) **Standards are to be applied to each facility. Those units with higher emissions rates and few if any controls need to be addressed as priority.**

d) **The standards for existing plants for 2010 must be at least as stringent as that set for new, modified and/or expanded coal plants.**

e) **Clarify criteria for the designation of new, modified and expanded plants.**

f) **Mandatory annual reporting and monitoring protocol to include:**
   - **Coal Facts: type and blend**
   - **Mercury concentration in coal (ppm) and total mercury (kg)**
   - **Total annual amount of mercury emitted (kg)**
   - **Net Generation, Capacity Factor**
   - **Mercury Emission Rate**
   - **Pollution controls specifically for mercury.**

g) **No exemptions for facilities emitting < 5 kg.**

h) **"Emissions Trading" in any form is not a viable mechanism for the elimination of toxins such as mercury.**

i) **All jurisdictional implementation plans and compliance strategies are to be in place by 2003 and reviewed in multi-stakeholder fora.**

j) **Facilities must develop a pollution prevention strategy.**

k) **"Risk-benefit and cost-benefit analyses" must incorporate health and societal benefits as well as the ensuing avoided costs over the long-term.**

Public multi-stakeholder review in 2005 to track:

- **Progress towards meeting targets and timelines;**
- **Pollution control technologies in place and planned;**
- **Pollution prevention strategies;**
- **Multi-pollutant benefits;**
- **Monitoring and reporting protocol;**
- **Jurisdictional implementation plans;**
- **The existing fleet of plants, closures and any proposals for new coal plants;**
- **Assessment of local, cumulative and long-range impacts of new, modified and existing coal plants.**

Facilities are required to supply the appropriate information to conduct an analysis for the reporting and monitoring protocol and the review.

Schedule for Compliance

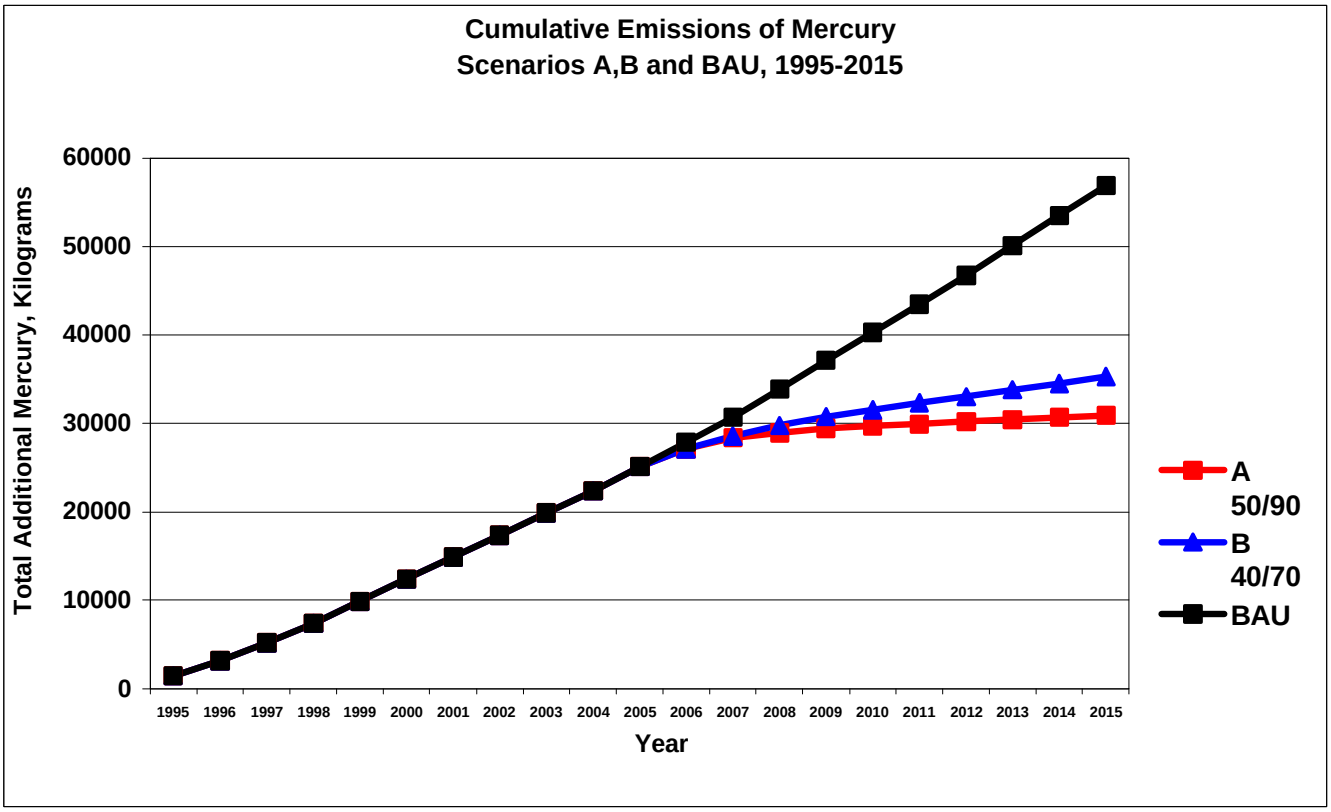
Schedule Year (or earlier)	**Actions to be Achieved**	**Mercury mg/MWH (emission rate)**		**Target – Objective 1999 base year (2500 kg - cap)**	
		Existing Facilities	**New Facilities**	**Kilograms Mercury**	**Per Cent Reduction**
2002	Set 2007 interim standard; 2010 standard (objective)			**1250** **250**	**50** **90**
2003	Mandatory Reporting and Monitoring Protocol				
2003	Jurisdictional Implementation Plans				
2005	Review of Standard				
2007	Compliance with interim standard			**1250**	**50**
2010	Compliance			**250**	**90**

Part D: Reduction Scenarios

Emission rate reductions for each and every facility to a uniform standard
Target the highest emitters, in terms of emission rate and actual emissions
All jurisdictions must show reductions.

Part E: Cumulative Emissions – The True Loading Picture:

Total cumulative emissions of mercury from coal-fired plants over a twenty-year period from Canada's coal-fired plants are in the order of 50-60 tonnes. What are the cumulative emissions over the lifetime of these facilities?



Part E: Outstanding Issues for MAG members

Setting the Baseline
New Plant CWS
Review Timeline for Reductions
Application of CWS
Bituminous/Sub-bituminous/lignite limit (mg/mwh)
Exemptions
Equal access to information
Year 2000 data – when will it be available
Membership of TWGs
Conferences
Confidentiality
Direction and Future Role of CWS – EPG MAG, in particular, TWG

Part F: Concluding Remarks - Messages to MAG and DC

Key components of the Harmonization Accord and the Standards Sub-Agreement are stakeholder participation and NGO representation. Therefore, all stakeholders in the MAG must be accorded equal opportunity and access to information in order to offer the best possible advice to the DC in the public interest.

Furthermore, it is paramount that the CWS standards process has regard first and foremost for prevention of releases of mercury and not run the risk of becoming an exercise driven by technological fixes and pollution control devices alone.

"When a pollutant is attacked at the point of origin – in the production process that generates it- the pollutant can be eliminated; once it is produced, it is too late."…
Barry Commoner, *Making Peace with the Planet*

Final Words

Set a standard now that will achieve significant reductions – 90%, in mercury emissions from coal-fired plants within 10 years
The standard must be enforceable (regulatory action required accordingly)
All jurisdictions required to design appropriate implementation plans to ensure compliance with the standard
Establish a Reporting and Monitoring Protocol
Provide information to the Public

A.T.

The following abstract is from a paper presented to International Association of Great Lakes Research (IAGLR) that was presented at their conference May, 2000.

Mercury – Canada-wide Standards and Coal-fired plants a Public Concern

Abstract

The author reviews the current Canada-wide Standards process for mercury with respect to coal-fired plants, the status on mercury emissions from these facilities in Canada, the projected trend, and the options being considered for reducing emissions. The links between air emissions from coal-fired plants to contamination of soil and water and the impacts on health and environment are made within the context of social and environmental justice issues. The prevailing message of the paper focuses on the role and significance of advocacy from the perspective of non-government organizations in effecting policy that reflects societal concerns within the context of setting standards. A critical analysis of the consultation process of Canada-wide Standards examines participation, inclusiveness, and diversity and the polarization and dynamics of the different "stakeholders". Strategies and action plans crafted by NGOs to counteract the resistance and rhetoric of the industry and pressure government are described. In presenting this paper, the author is showing the potential of NGOs as advocates to be the conduit for advancing the work of scientists and health professionals on mercury, and to bring this knowledge to the forefront of the public in order to influence policy and process.

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