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USEPA National Mercury Emissions Inventory and Role in Emissions Reduction Program For Electric Power Plants

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ABSTRACT
The US Environmental Protection Agency (EPA) has issued the Clean Air Mercury Rule (CAMR) to cap and reduce mercury (Hg) emissions from coal-fired power plants. In addition, the Clean Air Interstate Rule (CAIR) has recently been issued to significantly reduce SO2 and NOx emissions from power plants. These two rules will work together to address mercury, SO2 and NOx emission reductions simultaneously. When fully implemented, these rules will reduce utility emissions of mercury from 48 tons a year to 15 tons, a reduction of nearly 70 percent. The Hg reduction rule is based on various control techniques expected to be available within the next five years. A 'cap and trade' approach is used and provides flexibility in how states and territories allocate budget allowances.

Recent activities and decisions under the United Nations Environment Program (UNEP) are raising awareness of mercury pollution including the characterization of sources and emissions. This paper will describe how the U.S. Hg emissions inventory was prepared for the purpose of modeling air quality results and the Hg control program for electric generating utilities (EGUs). The discussion will highlight the source characterization, the use of speciation profiles, and the application of growth and control parameters to project future year emissions. References will be provided to the reader to learn more about the cap and trade approach and the control technology aspects of the mercury rule.

INTRODUCTION

The United States Environmental Protection Agency (USEPA) has issued the Clean Air Mercury Rule (CAMR) to cap and reduce mercury (Hg) emissions from coal-fired power plants. In addition, the Clean Air Interstate Rule (CAIR) has recently been issued to significantly reduce sulfur dioxides (SO2) and nitrogen oxide (NOx) emissions from power plants to impact ozone and particle pollution. The electric power sector is a major source of Hg, SO2, and NOx emissions, nationwide. These two rules will work together to address Hg, SO2 and NOx emission reductions simultaneously. The Hg reduction rule is based on various control techniques expected to be available within the next five years. It is anticipated that some plants may determine co-benefits from different control technologies to be the most cost-effective way to achieve multi-pollutant reductions. When fully implemented, these rules will reduce electric utility emissions of mercury from 48 tons a year to 15 tons, a reduction of nearly 70 percent. This rule limits mercury emissions from new and existing coal-fired power plants, and creates a market-based cap-and-trade program that will permanently cap utility mercury emissions in two phases: the first phase cap is 38 tons beginning in 2010, with a final cap set at 15 tons beginning in 2018. The cap and trade approach provides flexibility in how states and territories allocate budget allowances. More information about the cap and trade approach and the control technology aspects of the mercury rule (CAMR), as well as specific monitoring provisions and implementation requirements, may be obtained from the public docket located on http://www.epa.gov/ttn/atw/utility/utiltoxpg.html .

This paper describes how the EPA prepared and processed the base year and future year Hg emissions inventories needed to model air quality changes that could be expected from the emission control program for electric generating utilities (EGUs). The references for this discussion are the emissions inventory and air quality *technical support documents* for the CAMR. The following sections of this paper highlight the role of the national emission inventory in the rule making process, the level of detailed emissions information needed for that purpose, the relevance of source category code descriptions, and how the base year and projection year inventories were prepared and processed for use in the air quality model.

METHODOLOGY and RESULTS

In general, regulatory analysis for a rule such as CAMR integrates the following activities to arrive at state/ territory Hg emission budgets for a trading program:

Emission budgets
∟Benefits analysis
∟Air quality modeling
∟Emissions modeling
∟Base year/ projection year inventories

The level of data detail needed in the emission inventories is driven by the subsequent air program modeling and analysis requirements. To analyze the benefit of different control scenarios, base year emissions are projected to future year(s) and modeled for air quality changes. The photochemical air quality model requires that the base year and projected inventories of annual emissions be converted into gridded, chemically speciated, and hourly emissions. Throughout this conversion process known as emissions modeling, different types of unique source category characterization codes are used to keep large volumes of data cross-referenced for interim calculation routines. Many of the codes relevant to the Hg national emissions inventory and process modeling include:

- SCCs – source classification codes by type of process
- MACT – maximum achievable control technology codes to describe national hazardous air pollutant emission standards for specific source category processes
- SIC – North American standard industrial classification codes by different economic/ business sectors

The source types in the Hg national inventory for CAMR include – Point EGUs and non-EGUs; and non-Point stationary. Nonroad and on-road mobile source emissions were not relevant to the Hg inventory. The type of detail that characterizes these emission source types is summarized as follows:

Point Sources

For each process within individual facility:

- source classification code (SCC) to describe specific emitting processes, fuel type
- amount of fuel or other activity generating emissions
- pollutant emission rate (emission factor)
- operating schedule
- control device(s)/ efficiency
- emission release point latitude/ longitude
- stack height, exit gas temperature/ velocity
- SIC
- MACT code

Non-Point Sources

Process emissions aggregated by county geographic area:

- source classification code(SCC) to describe specific emitting processes, fuel type
- amount of activity generating emissions
- pollutant emission rate (emission factor)
- operating schedule
- SIC
- MACT code

Base Year Inventory

A base year Hg inventory for 2001 was used for the CAMR analysis which was congruent with the base year analysis done for the CAIR that targeted SO_2 and NOx emission reductions from power plants. The US national emission inventory is prepared comprehensively on a 3-year cycle, i.e., 1996, 1999, 2002, etc. The 2002 NEI was under development and the 1999 NEI was available in final form, so it was used to represent 2001 Hg emissions. The 1999 NEI was compiled from a variety of sources including the state and local agencies, tribal nations, and industry. The EPA also collected some of the data as part of regulatory programs. Data from these sources was merged with attention given to selecting the most reliable information for given categories, and to avoid duplication. Data was augmented as necessary to fill-in missing or erroneous stack parameters and geographic coordinates. Quality assurance and control procedures were accomplished with the help of state and local agencies and industry.

The modeling domain for CAMR included 48 states and parts of Canada and Mexico. The 2001 base year Hg inventory covered the 48 states. The point EGU and non-EGU, and non-point stationary source data included the type of detail listed above. The source category contribution to the 2001 Hg emissions is summarized in the following table. Canadian Hg emissions species data was available for year 2000 and was used to represent 2001 data. Data for Mexico was not available.

For the 2001 point source EGUs, the 1999 Hg NEI emissions data for the electric utility coal-fired generating units was replaced with more recent data obtained from the MACT regulatory program. In turn, the EGUs were replaced with the set of facilities defined in the National Electric Energy Database System (NEEDS) which serves as a target basis for the Integrated Planning Model (IPM), a tool that is systematically used to forecast cost and energy impacts to the power sector of the economy, and would be used to project the 2001 emissions to 2020. This replacement was done in order to ensure consistency for the EGUs between the base year and projected year inventories. More information on how the IPM was used to perform the cost, economic, and energy impact analysis for CAMR may be found in the regulatory impact analysis - Chapter 7 of the technical support document located on http://www.epa.gov/ttn/atw/utility/ria_final.pdf. Documentation for IPM can be found at www.epa.gov/airmarkets/epa-ipm.

For point non-EGU sources, the 1999 Hg NEI data for municipal waste combustion units (MWC) and the medical waste incinerators (MWI) were replaced with data in the draft 2002 NEI. Several industrial and regulatory process code assignments were corrected that would affect projection of future year emissions.

Summary of 2001 Base Emissions, Continental U.S.

Category Name	2001 Mercury Emissions (Tons)
Electric Generating Units defined and projected using the IPM Model	48.6
Gold Ores	11.5
Industrial, Commercial and Institutional Boilers and Process Heaters (all fuels), excluding 0.74 tons for the EGUs counted and projected using the IPM Model	11.2
Hazardous Waste Incineration	6.6
Mercury Cell Chlor-Alkali Plants	6.5
Municipal Waste Combustors	4.8
Portland Cement Manufacturing	2.4
Refuse Systems	2.1
Pulp and Paper Production	1.7
Stationary Reciprocating Internal Combustion Engines	1.3
Industrial Inorganic Chemicals, NEC	1.2
Petroleum Refineries – Catalytic Cracking, Catalytic	1.15

Reforming, & Sulfur Plant Units	
Residential Heating: Distillate Oil	1.1
Lamp Breakage	1.0
Lime Manufacturing	1.0
Sewerage Systems	0.9
Dental Laboratories	0.7
Other Categories (includes the sum of all categories having 1999 and 2020 emissions less than 1 ton)	7.5
Total (all categories)	**111.3**

Projection Year Inventory

The 2001 base year emissions were projected to 2020, generally through a process of applying growth and control factors. These factors may be applied to either the emissions or the activity. The general projection equations are:

Emissions-based:

$$E_{future\ yr} = E_{base\ yr} * GF * \frac{(100\% - \%Reduction)}{100}$$

Activity-based:

$$E_{future\ yr} = A_{base\ yr} * GF * EF_{future\ yr}$$

*Where…*The base year is 2001, and

- GF = Growth Factor specific base year to a specific future year
- %reduction = reduction expected from regulatory program
- A = activity
- EF = emission factor in future year (incorporates reduction expected from regulatory program)

For the Point EGU facilities, the Integrated Planning Model (IPM) performed the emission projections through a detailed, sector-specific analysis of growth and control implications. Process-specific emissions of mercury by species were provided by the IPM.

Generally, the controls account for expected source reductions from national regulatory programs already in place or scheduled. Information of specific process standards were obtained from rule background information and EPA staff responsible for the regulation. Some of the applied control information included facility-specific reductions reflecting known plant closings and planned retrofits for MWC and mercury cell chlor-alkali facilities, as well as voluntary reduction programs for four gold mines.

Growth factors account for future increases in emissions-generating activities, including for instance, population growth, where population is the activity surrogate which correlates with process emissions. Economic and energy models were utilized to forecast growth for some industrial sectors and assigned to processes by the SIC or SCC. Most of the source categories influenced by MACT process standards were assigned no growth, in part due to uncertainties in the original 1999 estimates.
The following table from the air quality modeling technical support document highlights the types and sources of information used to estimate the projected emissions for 2020.

Summary of Emissions Sources for 2001 and 2020 Mercury Emissions Inventories

Sector	Emissions Source	2001 Base Year	2020 Base Case Projections
Utilities - Electric Generating Units (EGU)	Power industry electric generating units (EGUs)	1999 National Emission Inventory (NEI) data	Integrated Planning Model (IPM) reflecting growth in Btu demand as well as regulatory policies implemented through 2020, such as the Clean Air Interstate Rule
Non-EGU point sources	Non-Utility Point	1999 NEI, with medical waste incinerator sources replaced with draft 2002 NEI	(1) Department of Energy (DOE) fuel use projections, (2) Regional Economic Model, Inc. (REMI) Policy Insight® model, (3) decreases to REMI results based on trade associations, Bureau of Labor Statistics (BLS) projections and Bureau of Economic Analysis (BEA) historical growth from 1987 to 2002, (4) Maximum Achievable Control Technology category growth and control assumptions
Non-point sources	All other stationary sources inventoried at the county level	1999 NEI, with medical waste incinerator sources replaced with draft 2002 NEI	same as above

*This table documents only the sources of data for the U.S. inventory. The sources of data used for Canada and Mexico are explained in the technical support memorandum and were held constant from the base year to the future years.

Processing Emissions for Air Quality Modeling

EPA used a photochemical air quality model, the Community Multiscale Air Quality (CMAQ) modeling system, to predict the levels of mercury deposition for a 2001 base year and a 2020 baseline reflecting co-control of mercury from implementation of the Clean Air Interstate Rule (CAR) as well as two control options for CAMR. The estimated changes in mercury deposition associated with the control options were then combined with fish tissue data for use in estimating health and welfare effects, e.g., the benefits analysis. CMAQ accounts for spatial and temporal variations as well as differences in the reactivity of mercury emissions in the atmosphere, and is the best available model for evaluating the impacts of the CAMR on U.S. mercury depositions.

In order to develop an Hg inventory ready for air quality modeling, the annual emission inventories were converted into a 36km gridded, hourly, and chemically speciated inventory. Chemical speciation data was used to convert ‘raw’ Hg emissions into the species needed by the CMAQ model - elemental mercury, gaseous divalent mercury, and particulate divalent mercury. Species profiles are assigned per SCC and MACT code. The Hg speciation profiles which were applied are listed in the emissions inventory technical support document.

Temporal factors were assigned by SCC and used to calculate hourly emissions for each process type. The majority of the source category emissions had a similar temporal pattern of:

- uniform by month;
- higher emissions during work week and higher on Saturday than Sunday; and,
- higher emissions in afternoon, lower emissions in the morning.

The following table from the air quality modeling technical support document indicates that a total of almost 115 tons of mercury were emitted across all sources in 2001. EGUs emitted a total of 48.6 tons, or 42.3 percent of mercury emissions across all sources during this base year. Almost 21 tons of the most readily deposited form of mercury, i.e., reactive gaseous mercury, were emitted by these utilities and therefore comprised 42.4 percent of their mercury emissions.

The 2020 baseline emissions shown accounts for increases in economic activity and population growth between 2001 and 2020 that lead to increased production in the utility and manufacturing sectors and hence increases in emissions over time, as well as the implementation of regulatory policies from MACT standards (primarily on non-EGU sources) and the CAIR controls (as applied to EGUs in the eastern U.S.) which decreases emissions over this time period. Total mercury emissions in 2020 are roughly 87 tons, reflecting a net reduction of almost 28 tons (or 24 percent) from 2001 levels. This table does not reflect the further Hg reductions realized by modeling the different control options that were also modeled and evaluated in the CAMR analysis.

Summary of Mercury Emissions by Species: 2001 and 2020 (with CAIR) Baselines

Emissions Source	Mercury Emissions Species (tons)			Total Mercury Emissions (tons)
	Elemental	Reactive Gaseous	Particulate	
2001 Base Year				
EGUs	26.26	20.58	1.73	48.57
Non-EGU Point	37.85	13.33	7.60	58.78
Non-point	5.05	1.53	0.96	7.54
Total, All Sources	69.16	35.44	10.29	114.89
2020 (with CAR) Baseline				
EGUs	25.72	7.87	0.83	34.42
Non-EGU Point	28.03	10.37	6.61	45.01
Non-point	5.69	1.30	0.77	7.76
Total, All Sources	59.44	19.54	8.21	87.19

CONCLUSIONS

Some of the technical issues involved in preparing emission inventories for regulatory analysis, such as described in this paper for the Hg inventories and CAMR, include the following:

- Optimize use of what data is available.
- Make conservative assumptions in light of uncertainties or lack of data, i.e., no growth assumptions, and application of default temporal and speciation profiles.
- Improve/ make consistent reference codes across databases to facilitate matching of data and co-mingling of available data.
- Maintain consistency between base year and projected year inventories.

EPA continues to study additional sources of mercury to improve the NEI mercury air emissions estimates. Those sources include mobile, petroleum refining, gold mines, and electric arc furnaces.

Significant reduction in air emissions have been achieved in the U.S. Additional reductions in mercury air emissions are expected due to the implementation of the Clean Air Mercury Rule (CAMR) and other regulatory programs discussed in this paper. The role of emissions inventories is very important in the air quality management process to facilitate regulatory analysis and understand the impact and benefits of air pollution control programs

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Discussions with, and presentation materials by, listed co-authors.