Projection of Hazardous Air Pollutant Emissions to Future Years

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ABSTRACT

Projecting a hazardous air pollutant (HAP) emission inventory to future years can provide valuable information for air quality management activities such as prediction of program successes and helping to assess future priorities. We have projected the 1999 National Emission Inventory for HAPs to numerous future years up to 2020 using the following tools and data:

- the Emission Modeling System for Hazardous Air Pollutants (EMS-HAP)
- the National Mobile Inventory Model (NMIM)
- emission reduction information resulting from national standards and economic growth data.

This paper discusses these projection tools, the underlying data, limitations and the results. The results presented include total HAP emissions (sum of pollutants) and toxicity-weighted HAP emissions for cancer and respiratory noncancer effects. We show these projections, along with historical emission trends. The data show that stationary source programs under section 112 of the Clean Air Act Amendments of 1990 and mobile source programs which reduce hydrocarbon and particulate matter emissions, as well as toxic emission performance standards for reformulated gasoline, have contributed to and are expected to continue to contribute to large declines in air toxics emissions, in spite of economic and population growth. We have also analyzed the particular HAPs that dominate the various source sectors to better understand the historical and future year trends and the differences across categories.

INTRODUCTION

There are numerous reasons to project how emission inventories will change in future years. For criteria pollutants, emissions are projected to future years routinely by EPA, States and Regional Planning Organizations to support control strategy development for ozone, PM and visibility. Future year emissions with and without control strategies are input into an air quality model to determine the impacts of ozone and fine particulate matter. Emission projections for hazardous air pollutants (HAPs) are not routinely done, as they are for criteria pollutants, as the inventory for HAPs is relatively new. The first comprehensive air quality model-ready national inventory for HAPs containing site-specific estimates, called the National Toxics Inventory, was developed for the year 1996.[1]

Emission projections for HAPs can similarly provide valuable information for air quality management activities, such as prediction of program successes and helping to assess future priorities. We can combine the effects of rules and policies on various source sectors to see how they affect future year emissions. We can also determine, by looking at emissions growth, the emissions that could have resulted in the absence of such programs. Emission projections can be used to generate interim inventories for years for which the inventory has not yet been developed. For example, the latest HAP inventory available in the 2004 year is the 1999 NEI. We can use projections to approximate a 2004 inventory if needed. We can apply toxicity weighting to emission projections to estimate changes in key source categories and priority HAPs. We can also used projected emissions to help determine the impacts of various emission control strategies. For example, projected emissions of particular HAPs that are on the list of Mobile Source Air Toxics[2] can be used to provide information for the Mobile Source Air Toxics Rule to be proposed later in 2005.

The projections presented here include all HAPs listed in Section 112 of the Clean Air Act except mercury, dioxins, chloramben, DDE and radionuclides.

This paper discusses these projection tools, the underlying data, limitations and the results. It is intended for audiences that have some working knowledge on emission inventories and their use in air toxics characterization.

BODY

Overall Methodology

We projected emissions for nearly all HAPs from 1999 to numerous future years up until 2020. To project emissions to these future years, we considered the effect of growth in activity, which, depending upon the source category could be positive or negative, and regulatory programs which serve to further reduce 1999 emissions. Emissions growth was primarily determined from information on projections of sector specific economic activity, population growth, fuel consumption, vehicle miles traveled and nonroad equipment populations. For stationary sources, HAP reductions were determined primarily from the regulatory programs under Section 112 such as the Maximum Achievable Control Technology (MACT) standards and Section 129 of the Clean Air Act which include over a hundred National Emission Standards for Hazardous Air Pollutants and a number of solid waste rules. For mobile sources, HAP emissions reductions included impact of numerous control programs addressing fuels and vehicles for highway vehicles, and nonroad sources.

Methodology for Stationary Sources

For nearly all stationary sources (point and non-point source inventories), we used the Emission Modeling System for Hazardous Air Pollutants, Version 3.0 (EMS-HAP)[3] to apply growth and control factors to the 1999 NEI, record by record. EMS-HAP was not used to project emissions from Medical Waste Incinerators (MWI). For this category, as directed by the project lead, future year emissions are assumed to remain constant at 2002 levels, so rather than use EMS-HAP, we used 2002 emission data in place of 1999 emissions for all future years.

The general methodology for projecting stationary source emissions using EMS-HAP is as follows:

Future Year Emissions = Base Year Emissions * Growth Factor * (100%-%Reduction)/100

The actual equations used by EMS-HAP also allow the application of a "new source" reduction to a fraction of the emissions to allow for a different level of emission reduction to be applied to a portion of the emissions. In addition, if the source is already controlled, and the value of the overall control efficiency is provided in the emission inventory, EMS-HAP will adjust the percent reduction (% Reduction) based on the overall control efficiency value provided in the inventory. The actual projection equations are provided in Chapter 6 (PtGrowCntl) of the EMS-HAP User's Guide.[3]

Stationary Source Growth

EMS-HAP allows growth factors to be applied to the inventory on either a national, state or county level basis, based on one of the following inventory codes that describe the source: (1) MACT which identifies an emission source as a belonging to a particular regulatory category or subcategory; (2) Standard Industrial Classification (SIC), which identifies the emission source as a particular establishment (see http://www.osha.gov/pls/imis/sic_manual.html for the definitions); (3) Source Category Code (SCC), which defines the source using EPA's coding system for the NEI. The MACT and SCC code definitions are contained in the code tables supplied with the NEI. Note that even though the code is called "MACT", it is used also for other regulations besides MACT such as Section 129 rules. The hierarchy built into EMS-HAP is to use a MACT-based growth factor first, followed by an SIC-based and the SCC-based. The most detailed geographic level is used first (e.g., a state-specific growth factor replaces a national growth factor). EMS-HAP does not have the capability to apply growth factors to specific point source facilities, nor can they be applied differently for the different pollutants for a particular source category.

For stationary sources, growth factors were developed using three primary sources of information:

- Regional Economic Model, Inc. (REMI) Policy Insight® model, version 5.5;
- Regional and National fuel-use forecast data from the U.S. Department of Energy, Annual Energy Outlook for the years 2004, 2001 and 2002;
- Rule development leads or economists who had obtained economic information in the process of rule development.

The first two sources of information were also used in projecting criteria pollutant emissions for EPA's 2005 Clean Air Interstate Rule.[4] Earlier versions of REMI and AEO were also used to develop the Economic Growth Analysis System (EGAS) 4.0, which provides growth factors from 1996 up to 2020.[5]

The REMI model, version 5.5 (currently being used as a source of data in the development of the EGAS 5.0, http://www.epa.gov/ttn/ecas/egas5.htm) forecasts economic activity by region and for individual sectors of the economy. By making assumptions about which economic indicators can represent emissions growth, growth factors can be developed for projecting emission inventories. We developed state-specific growth factors, for the specific SIC and SCC codes in the 1999 inventory.[6] A review of these growth factors for the development of the Clean Air Interstate Rule projected inventories, led to changes to about a dozen SIC code-based growth factors where they were unrealistic or highly uncertain. They were replaced with data (national-level) from industry forecasts, bureau of labor statistics (BLS) projections and Bureau of Economic Analysis (BEA) historical growth from 1986 – 2002.

The Annual Energy Outlook presents forecasts of energy supply, demand and prices by energy type through 2025 based on results of Energy Information Administration's National Energy Modeling System. (http://www.eia.doe.gov/oiaf/forecasting.html) These data were used to develop growth factors for emission sources related to energy use, such as residential heating. The data are provided at a division level, with the country divided into nine divisions, for some sectors (e.g., residential fuel use),

and at the national level for more detailed industrial sectors (e.g., paper). Growth factors were developed at the most detailed geographic scale (e.g., developed State-level growth factors from the division information) and sectors available. The AEO data were mapped to SCCs.

We also computed growth factors from data provided by project leads of regulatory development efforts for particular source categories. For example, a number of source categories were projected to remain flat or decrease, and for these categories, we assigned a growth factor of 1.0. All MACT-based growth factors provided by project leads were at the national level.

In addition to the three primary sources for growth factors described above, we used "no growth" assumptions (growth factor =1.0) for wildfires and prescribed burning. For HAPs emitted from coal-burning utility boilers, we used Integrated Planning Model (IPM) run results from the CAIR proposal to develop State-specific growth factors based on future year projected coal consumption.[7]

For refueling emissions, which are related to mobile sources but inventoried as stationary sources, we developed SCC-based growth factors that accounted for both growth and reductions, using the same source of data we used to project mobile sources. This is explained below on the section for mobile sources.

Stationary Source Reductions

Emission reductions were applied to the grown emissions to account for regulatory efforts which are expected to reduce HAPs from 1999 levels. The percent reductions we determined were primarily based on estimates of nationwide-reductions for specific HAPs or for groups of HAPs from a source category or subcategory as a result of regulatory efforts. These efforts are primarily the MACT and Section 129 standards, which are described at http://www.epa.gov/ttn/atw/eparules.html. We determined percent reductions, and whether they apply to major only or both major and area sources, for the various rules from rule preambles, fact sheets and through the project leads (questionnaire and phone calls). A major source is defined as any stationary source or group of stationary sources located within a contiguous area and under common control that has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants; the status of a point source as "major" is indicated in the NEI by the field called "FACILITY CATEGORY". For some rules, percent reductions were provided for specific HAPs or groups of HAPs (e.g., all metals, or all volatiles) rather than a single number for all HAPs in the categories. We also received information on plant closures for several categories such as coke ovens and municipal waste combustors. For the "utility boilers coal" category, we assumed that the acid gases (hydrochloric acid, hydrogen fluoride and chlorine) would be reduced by the same amount as SO2 due to co-benefits of potential controls. We computed State-level SO2 reductions using SO2 projected emissions from the Integrated Planning Model runs done for proposed CAIR[7] and applied these reductions to the acid gas emissions. Emission reductions were generally applied in EMS-HAP by MACT code; some were HAP and MACT specific, some were SCC and MACT specific. Site specific reductions such as plant closures or estimations of reductions expected from particular facilities in the source category, were applied by the EMS-HAP site id; process specific, site specific reductions used the SCC as well.

A list of the source categories to which reductions were applied in EMS-HAP, either to facilities in the category or the entire category, is presented in Table 1. Note that this does not include the impacts of all of the rules, only those for which we were able to estimate HAP emission reductions and for which the compliance date was later than 1999, or for which information on closures was obtained. In addition, if the inventory did not have emissions for which the rule was expected to impact, then that was also left out of the table. It also does not include reductions from MWI, as discussed earlier.

Table 1. Summary of Categories for which reductions were applied in EMS-HAP

Category	Category
Amino/Phenolic Resins Production: POLYMERS & RESINS III	Organic Liquids Distribution (Non-Gasoline)
Ammonium Sulfate - Caprolactam By-Product Plants: THE MON	Pesticide Active Ingredient Production
Asphalt roofing and Processing	Petroleum Refineries - Catalytic Cracking, Catalytic Reforming, & Sulfur Plant Units (10 yr)
Boat Manufacturing	Petroleum Refineries - Other Sources Not Distinctly Listed (4yr)
Brick and Structural Clay Products Manufacturing	Pharmaceuticals Production
Carbon Black Production	Reinforced Plastic Composites Production
Carbonyl Sulfide (COS) Production	Phosphate Fertilizers Production& Phosphoric Acid Manufacturing
Cellulose products manufacturing	Plywood and Composite Wood Products
Commercial/Industrial Solid Waste Incineration (CISWI)	Polyether Polyols Production
Coke Ovens: Charging, Topside and Door Leaks	Portland Cement Manufacturing
Coke Ovens: Pushing, Quenching, & Battery Stacks	Pulp & Paper Production – Combustion & Noncombustion.
Cyanide Chemicals Manufacturing	Refractories Products Manufacturing
Ethylene Processes	Rubber Tire Production
Flexible Polyurethane Foam Production	Secondary Aluminum Production
Friction Products Manufacturing	Secondary Lead Smelting
Hazardous Waste Incineration and its subcategories: Commercial Haz. Waste Incinerators, On-Site Haz. Waste Incinerators, Cement Kilns, Lightweight Aggregate Kilns	Site Remediation
Industrial/Commercial/ Institutional Boilers & Process Heaters	Solvent Extraction for Vegetable Oil Production
Industrial/Commercial/ Institutional Boilers & Process Heaters (Coal)	Stationary Reciprocating Internal Combustion Engines
Integrated Iron & Steel Manufacturing	Surface coating related categories: • Auto & Light Duty Truck • Wood Building Products • Large Appliances • Metal Can • Metal Coil • Metal Furniture • Miscellaneous Metal Parts • Paper & Other Webs • Plastic Parts & Products • Fabric Coating Dying and Printing • Printing/Publishing
Iron Foundries	Steel Pickling - HCL Process
Leather Tanning & Finishing Operations	Taconite Iron Ore Processing
Lime Manufacturing	Viscose Process Manufacturing
Manufacturing of Nutritional Yeast	Wet-Formed Fiberglass Mat Production
Mineral Wool Production	Wool Fiberglass Manufacturing
Municipal Solid Waste Landfills	Utility Boilers: Coal
Miscellaneous Organic Chemical Products & Processes	
Miscellaneous Coatings Manufacturing	
Municipal Waste Combustors	
Primary Aluminum Production	
Primary Copper Smelting	
Primary Magnesium Refining	
Secondary Aluminum Production	
Stationary Reciprocating Internal Combustion Engines	
Natural Gas Transmission & Storage	
Off-Site Waste and Recovery Operations	
Oil & Natural Gas Production	

Methodology for Mobile Sources

For all mobile source categories except commercial marine vessels, locomotives, and aircraft, we used EPA's Office of Transportation and Air Quality's (OTAQ) new emissions inventory modeling system for highway and nonroad sources, the National Mobile Inventory Model (NMIM).[8, 9, 10] NMIM develops inventories using MOBILE6.2, NONROAD, and model inputs stored in data files. The version of NMIM used in this assessment includes, NONROAD2004, which was also used in the recent Clean Air Nonroad Diesel Rule.[11] In addition to criteria pollutants, NMIM can currently produce 13 gaseous

hydrocarbons, 16 polycyclic aromatic hydrocarbons, 4 metal compounds and 17 dioxin and furan congeners, for any calendar year 1999 through 2050.

For purposes of these projections, NMIM outputs for 1999, 2007, 2010, 2015 and 2020 were used to develop future year to 1999 air toxic inventory ratios, which were then applied to 1999 NEI inventory estimates by SCC, county and HAP. In cases where the 1999 NEI included aggregated or different categories other than those in NMIM, we aggregated NMIM results prior to applying ratios. For example, California reported HDDV emissions in the 1999 NEI as an aggregated HDDV "total" vehicle type rather than the specific HDDV classes (e.g., Class 2B, Class 3, 4, and 5). Thus, we aggregated NMIM HDDV results for California in order to apply a projection ratio to the HDDV "total" emissions. In the event that the NEI had HAPs not covered by NMIM (resulting from a State or Local Agency inventory submission), we developed ratios based on NMIM PM or VOC results.

Future year MOBILE and NONROAD inputs include future year VMT and fuel parameters, and future year equipment populations. We used the future year VMT developed for the CAIR rule.[5, 12] Fuel parameters for future years were developed by applying additive and multiplicative factors obtained from refinery modeling to base year fuel properties. In general, multiplicative adjustment factors were used to calculate future year gasoline parameters (i.e., future year parameter = base year parameter x adjustment factor). However, additive adjustment factors were used to calculate future year parameters for E200, E300, and oxygenate market shares (i.e., future year parameter = base year parameter + adjustment factor). The current database assumes no Federal ban on MTBE, but does include State bans.

We developed projected commercial marine, locomotive, and aircraft HAP inventories using information provided by EPA's OTAQ. For gaseous HAPs, emissions were projected by applying ratios of future year VOC to 1999 national level 50 state VOC inventory estimates by SCC code. Future year VOC were provided by OTAQ. For polycyclic aromatic hydrocarbons, PM ratios were used. Metal inventory estimates were projected to future years based on activity estimates. Future year VOC, PM and activity estimates were provided by OTAQ. For commercial marine vessels and locomotives, these data were developed for EPA's year 2004 Clean Air Nonroad Diesel Rule.[13]

Locomotive activity was projected using fuel consumption data from the Energy Information Administration. For commercial marine vessels, projected equipment populations from 1998 Power Systems Research (PSR) data were used to develop factors. These data were provided by EPA's OTAQ.

To project emissions from aircraft and from aviation gas distribution emissions, we developed and applied growth factors (in EMS-HAP) to 1999 emissions based on landing and take off data. The Federal Aviation Administration's Terminal Area Forecast System (TAF) (http://www.apo.data.faa.gov/faatafall.HTM model provided landing and take off data for 2002-2010, inclusive, 2015 and 2020, associated with commercial aircraft, general aviation, air taxi and military aircraft. These four categories map directly to the inventory categories for aircraft emissions. The TAF data were summed across airports to create growth factors at the national level. The general aviation growth factors were used for aviation gas distribution emissions.

Results

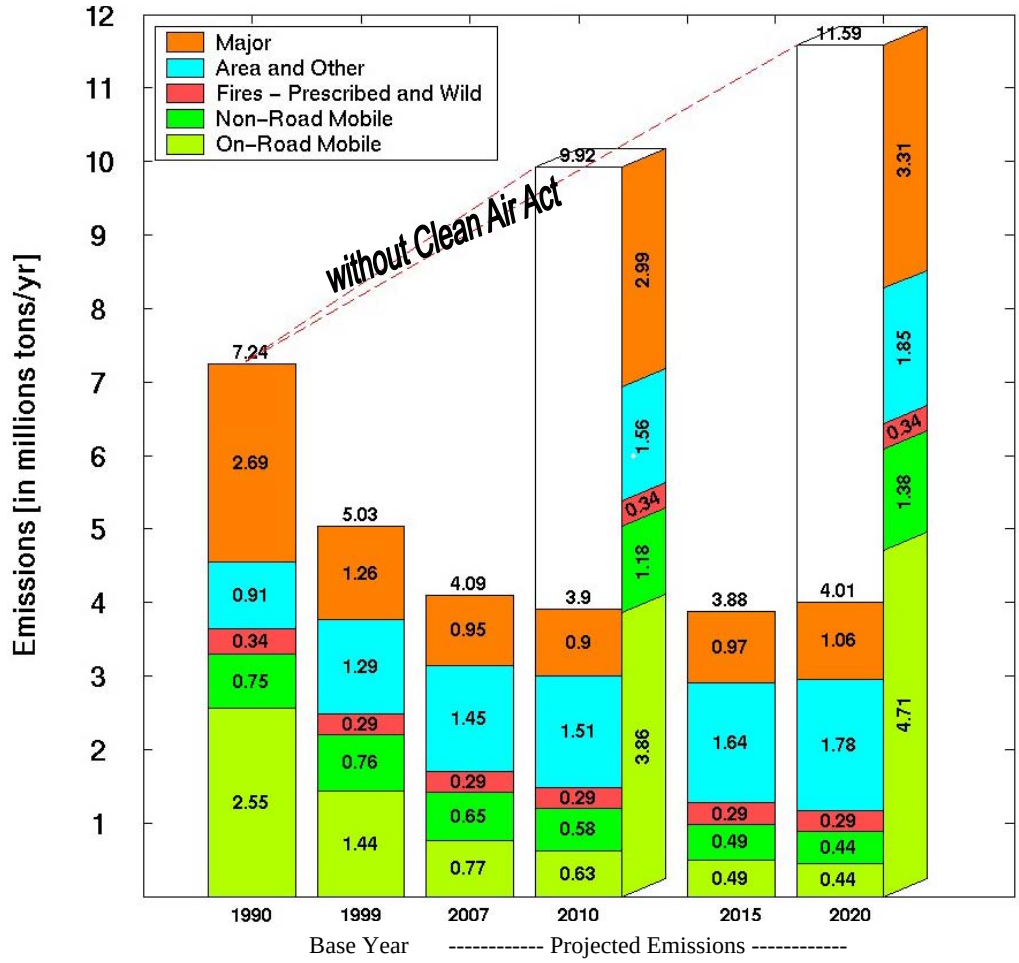
Figure 1 shows the emissions for all HAPs, summed by broad source sector at the national level. Here we provide data for the same source sectors used in the National Air Toxics Assessment (www.epa.gov/atw/nata): Major, Area and Other, Onroad and Nonroad. However, we have separated out two categories from "Area and Other" (wildfires and prescribed burning) and present those in a

separate sector which we call "Fires – Prescribed and Wild." For 1999, the wildfire emissions make up approximately 70% of the total fire emissions.

As noted in Figure 1, no reductions associated with the residual risk program or the new area source standards (e.g., those not covered by the MACT program) are included. The reductions associated with these programs were not available at the time of this projection. These programs would likely lower the projected emission estimates from stationary sources for 2007 and subsequent years.

The 1990 toxics inventory, which is not an air quality model-ready inventory, but does include county-level emissions, is included as an additional point of reference. While this inventory does help provide information on the historical emission trend, it should be noted that for key categories, particularly fires, the methodology used for 1990 has not been updated to match the method used for the 1999 NEI.

Figure 1. Historical and Future Year Emission Trends for all HAPs for the U.S.



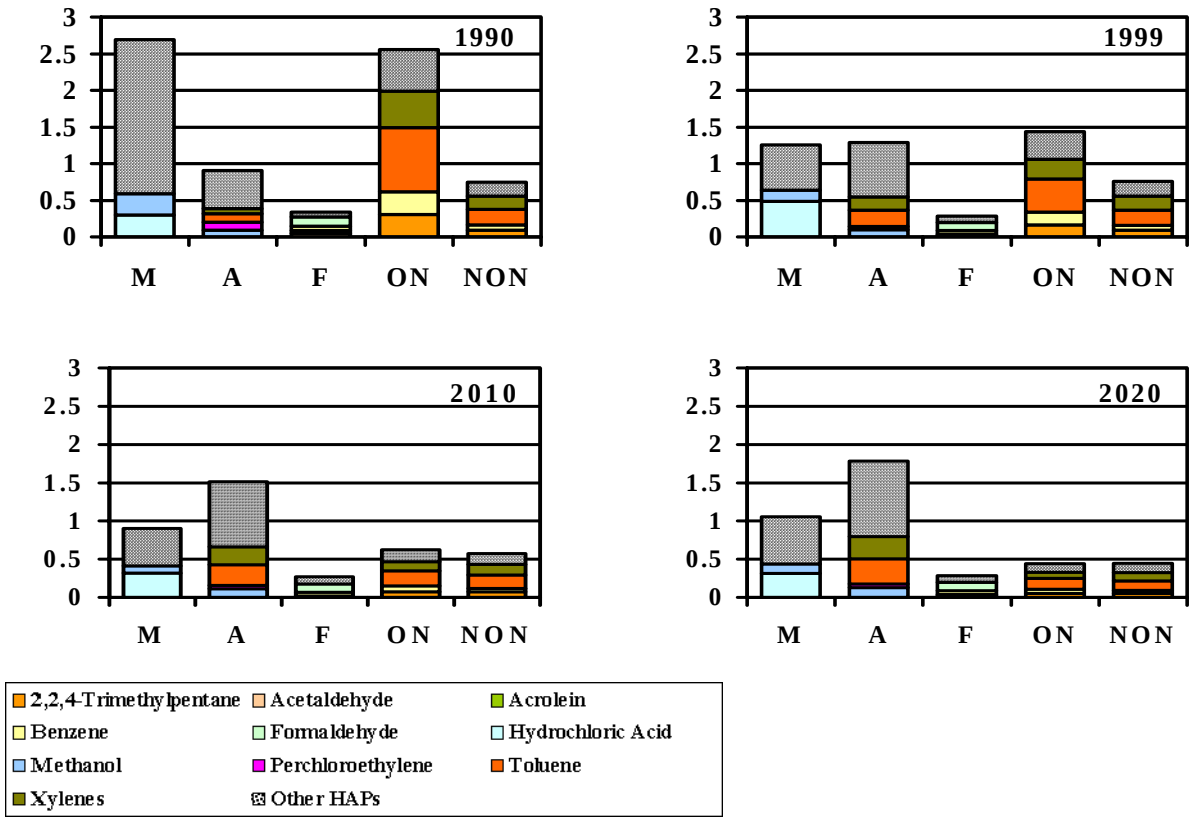
* After 2010, stationary source emissions are based only on economic growth. They do not account for reductions from ongoing toxics programs such as the urban air toxics program, residual risk standards and area source program, which are expected to further reduce toxics. In addition, mobile source reductions are based on programs currently in place. Programs currently under development will result in even further reductions.

In Figure 1, we also include, for 2010 and 2020, a scenario "without Clean Air Act" in which no reductions in emissions as a result of control programs are included. In this figure, we retained the 1990 emissions for fires for the "without Clean Act" case. The results show that, without the air toxics programs implemented from 1990 to the early 2000's, total air toxics emissions would have increased by 50% from 1990 to 2020; however, as a result of these programs, we expect a 40% decrease. As can be seen, all source sectors except for "Area and Other," which includes stationary sources that do not meet the major source threshold and non-industrial sources such as residential heating and use of consumer solvents, decrease between 1990 and 2010. After 2010 the emissions from major sources begin to increase. This is because the MACT program compliance dates are prior to 2010, and we did not

include the impact of the residual risk program due to the newness of this program. It should be noted that with regards to the "Area and Other" sector, we did not include the impact of area source standards that had not yet been proposed by 2004. Thus, as these standards get developed, we would expect future emissions to be lower. Future-year mobile source emissions are also expected to decrease even more than shown in Figure 1 as a result of future programs that are now being developed such as the Mobile Source Air Toxics Rule, additional standards for small nonroad gasoline engines, and standards for commercial marine vessels and locomotives.

Figure 2 shows the key HAPs that contribute to total emissions in each of the source sectors for each of the years. Only pollutants whose contribution was 10% or more are broken out individually; the remainder were summed into the group "other" (top of each bar).

Figure 2. Individual HAP contributions to projected HAP emissions (millions of tons). M=major sources, A=Area and Other sources, F=fires (wild and prescribed), ON=onroad sources, and NON=nonroad sources.



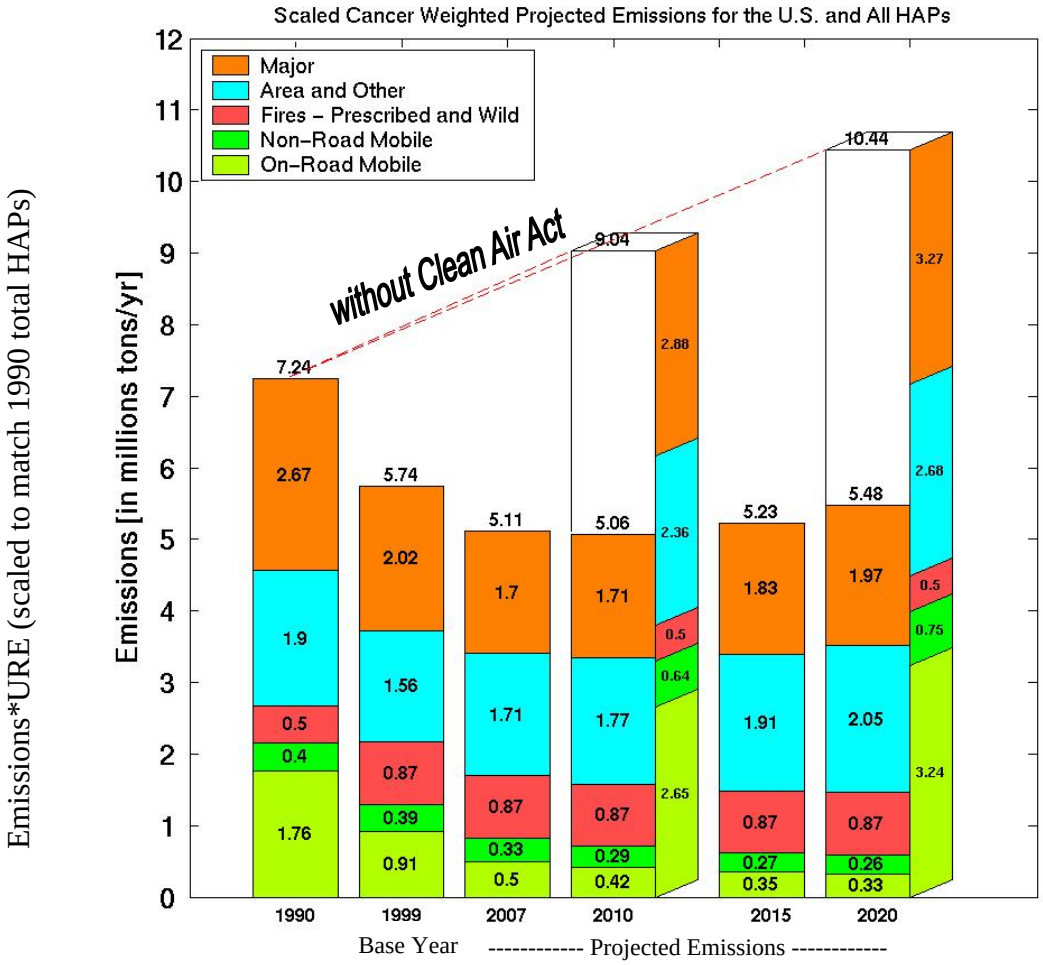
As can be seen from Figure 2, no single HAP dominates the sum of HAPs in any of the years, however, hydrochloric acid stands out in the major source bars, and toluene stands out in the onroad mobile bars, particularly in 1990 and 1999.

We have also developed emission projections that can serve as a more appropriate surrogate for risk by estimating emissions trends in a toxicity-weighted format. We have multiplied the emissions of each HAP by a weighting factor proportional to its relative toxicity, based on dose-response values associated with long-term (chronic) inhalation exposure for cancer and noncancer effects. For the noncancer effects we aggregated only those HAPs that affect the respiratory system. The values used are consistent with those used in the 1999 NATA Assessment and can be found at http://www.epa.gov/ttn/atw/toxsource/summary.html.

Figures 3 through 6 show the trends in toxicity-weighted ("tox-weighted") emissions for cancer and noncancer effects. The tox-weighed tons were adjusted so that the total emissions for 1990 remained at 7.2 million tons to allow for a direct comparison with un-weighted emissions.

The seemingly anomalous trends for fires between 1990 and 1999 for the un-weighted and tox-weighted emissions resulted from the difference in methodology between 1990 and 1999 fires calculations. As discussed in later in the section on uncertainties, these figures cannot be used to elucidate trends due to these methodology differences.

Figure 3. Historical and Future Year Emission Trends of HAPs, Toxicity-Weighted For Cancer for the U.S.



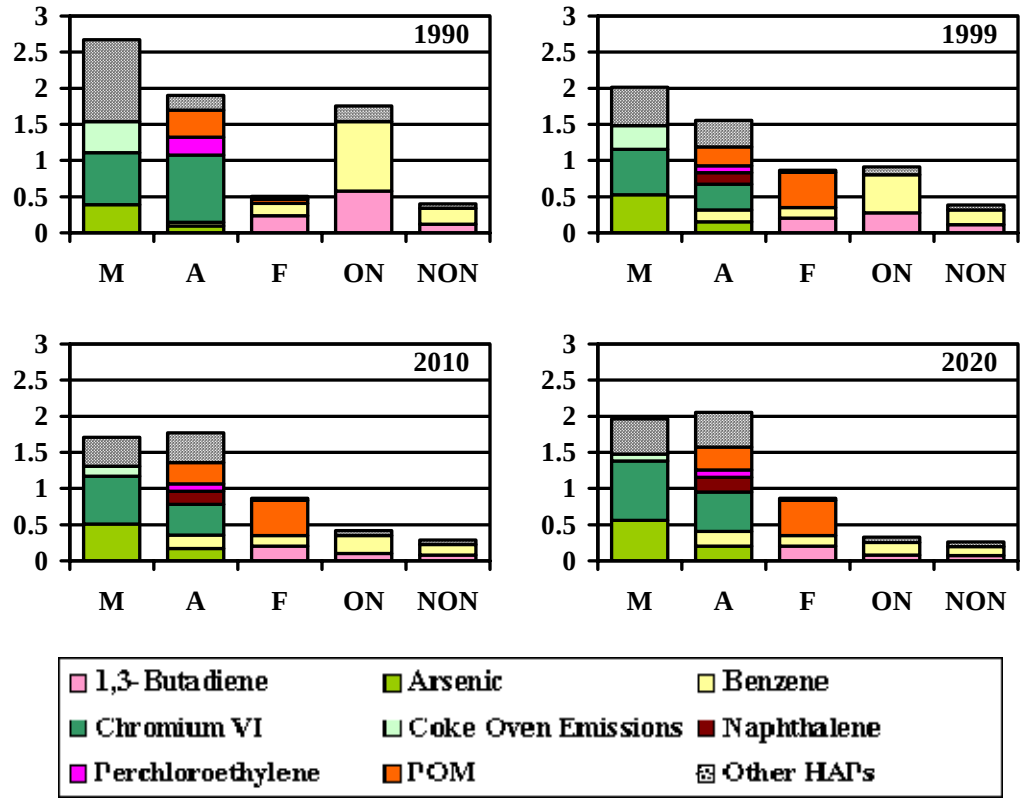
* After 2010, stationary source emissions are based only on economic growth. They do not account for reductions from ongoing toxics programs such as the urban air toxics program, residual risk standards and area source program, which are expected to further reduce toxics. In addition, mobile source reductions are based on programs currently in place. Programs currently under development will result in even further reductions.

Figure 3 shows the tox-weighted emissions for cancer, aggregated across all HAPs that have dose-response values for inhalation. Total tox-weighted emissions for cancer show a similar trend to un-weighted tonnage, but the reductions are smaller; total emissions decrease around 24% in the toxicity-weighted case as opposed to 44% in the un-weighted case. The mobile source un-weighted tonnages better track the toxicity-weighted emissions, in that un-weighted tonnage decreases by 73% between 1990 and 2020 and toxicity weighted tonnage decreases by 72%. This is due to the fact that mobile source emissions are dominated by the organic HAPs which are similarly impacted by VOC controls.

Figure 4 helps to further illustrate this point by showing the prominent HAPs for the tox-weighted emissions for cancer for each of the source sectors shown in Figure 3. In Figure 4, it can be seen that

coke ovens, hexavalent chromium and arsenic are the key major source HAPs that influence tox-weighted cancer risk, yet their total tonnage is extremely small compared to the tonnage of other HAPs emitted by major sources. In 1999, for example, they account for only 0.14% of the total major source tons. For mobile sources benzene and 1,3-butadiene are the key HAPs; they comprise 13% of the total mobile source tonnage in 1999 and they are reduced by a similar percentage as toluene and xylene, which comprise the majority of the mobile inventory.

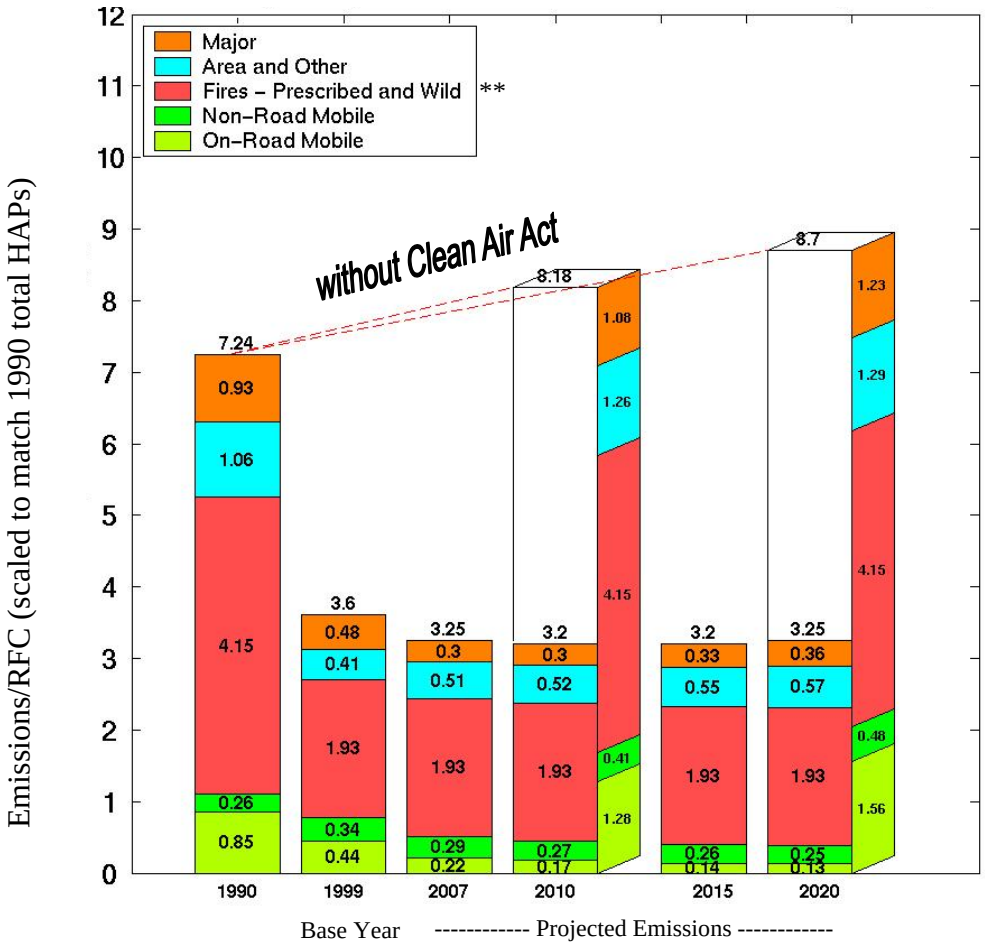
Figure 4. HAP contributions to toxicity-weighted emissions for cancer



One can also see, in the historical inventories, the impact of reductions of certain HAPs on the toxicity-weighted emissions that can be readily linked to our programs. In particular, noticeable decreases can be seen in perchloroethylene and hexavalent chromium in the "Area and Other" source sector. These pollutants are dominated by the dry cleaning and chromium electroplating source categories, for which MACT regulations were developed in the early 1990's.

The tox-weighting trends for noncancer effects, shown in Figures 5 and 6, have similar features to the un-weighted and tox-weighted for cancer trends regarding total emissions and mobile source emissions, but show large differences for stationary sources. First, the fires sector shows a significant decrease. Because the fires emission methodology was different in 1990, this above plot cannot show the real nature of the trend. For Area and Other sources, emissions are seen to decrease rather than increase between 1990 and 1999, and for stationary sources, the tox-weighted for noncancer effects decrease between 1999 and 2007 is larger than the decrease in un-weighted tonnage shown in Figure 1.

Figure 5. Historical and Future Year Emission Trends of HAPs, Toxicity-Weighted For Noncancer Effects for the U.S., For a Base Year of 1999.

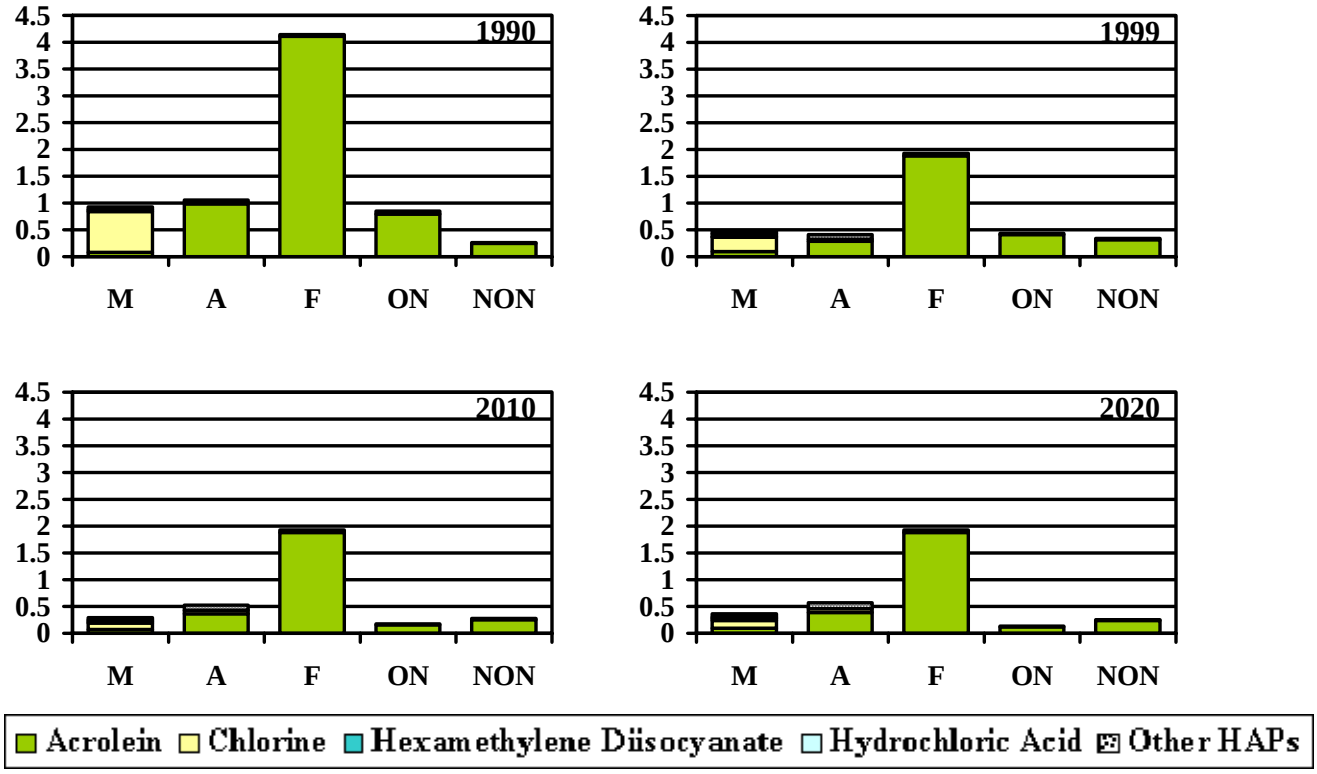


* After 2010, stationary source emissions are based only on economic growth. They do not account for reductions from ongoing toxics programs such as the urban air toxics program, residual standards and area source program which are expected to further reduce air toxics. In addition, mobile source reductions are based on programs currently in place. Programs under development will result in even further reductions.

** toxicity-weighted emissions for non cancer effects from fires are driven by acrolein, which is primarily emitted from combustion sources.

Figure 6 shows the contribution of HAPs to the toxicity-weighted trends for noncancer effects. As can be seen, acrolein dominates all categories other than major sources. Chlorine dominates major sources, with reductions seen between 1990 and 1999 and additional reductions expected in the future as a result of expected primary magnesium reductions and co-benefits expected by the proposed Clean Air Interstate rule. Primary magnesium refining and primary smelting and refining of nonferrous metals (except copper and aluminum) are the two dominant source categories for chlorine and experience the largest decreases between 1990 and 1999. In 1990, they comprise over 90% of the major source emissions for chlorine.

Figure 6. Individual HAP contributions to projected toxicity-weighted (for noncancer effects) HAP emissions (in millions). M=major sources, A=Area and other sources, F=fires (wild and prescribed), ON=onroad mobile sources, and NON=nonroad mobile sources.



Uncertainties and Data Issues

Uncertainties in the results arise from uncertainties and known issues with the input data. We did not perform a quantitative study on the uncertainty nor a sensitivity analysis on the results; however, we present the known issues and a qualitative interpretation of how they may affect the results. The input data are: the historical (1990) emissions, the base year (1999) emissions, the growth information, and the reduction information.

The main issue with the 1990 emissions is the methodology inconsistency for some categories, in particular, the open burning categories (e.g., wild fires, prescribed burning, structure fires). Thus, in the figures shown in the results section, the difference between the fires sector between 1990 and 1999 cannot be used for trends purposes. This issue also affects the Fires and "Area and Other" sector bars in Figures 5 and 6 because the toxicity-weighted emissions for noncancer effects for these sectors are dominated by the open burning categories.

For the 1999 NEI, there are a number of known or suspected issues for stationary source emissions listed on the emission inventory website (http://www.epa.gov/ttn/chief/net/1999inventory.html) in a file called "1999 NEI potential HAP errors." While the issues listed are generally limited to specific geographic areas and are not expected to influence national-level results, issues related to pollutants that drive toxicity-weighted emissions may be important. Of these, it is expected that issues related to acrolein are most likely to affect the results for noncancer effects. Another uncertainty concerning the base year inventory is the proper identification of sources using the inventory codes (MACT, SIC and SCC); as

discussed in the methodology section, these codes are greatly utilized for applying growth and reduction factors.

It is difficult to even qualitatively determine the impact of the growth and reduction information on the resulting projections, but we will list the uncertainties. The growth information is uncertain for a number of reasons. For most sources, activity growth is used as a surrogate for emissions growth, which may not be appropriate for some industry sectors. In addition the growth information available is from economic models, is generally specific to broad industry categories, and is not always resolved geographically. The stationary source reductions are uncertain because they are generally based on an industry-average reduction (although we have used facility-specific reductions where available). It is not expected this uncertainty has an impact on national-level results.

There are significant uncertainties in the mobile source inventories as well. For some source sectors, such as highway and nonroad diesel engines, there are limited toxic emissions data. For nonroad equipment, data on activity (hours of use) are also uncertain and information on the effect of deterioration on emissions is limited. For nonroad equipment, there are also significant uncertainties associated with allocating nonroad equipment emissions from the national to the local level. As with all inventory modeling, there are greater uncertainties in projection year estimates. For example, there are limited data on emissions from advanced technology vehicles and engines which will comply with planned future emission standards and inferences must sometimes be made regarding levels of emission deterioration and performance under various conditions. Also, as with stationary sources, activity is estimated using economic projections with similar inherent limitations.

CONCLUSIONS

We have projected HAP emissions to future years at a national-scale and have looked at the basis for the resulting trends in both future and historical emissions. The data show that the Clean Air Act has been effective at reducing overall tonnage of air toxics. The stationary source programs under section 112 of the Clean Air Act Amendments of 1990 and the mobile source programs which reduce hydrocarbon and particulate matter emissions, as well as toxic emission performance standards for reformulated gasoline, have contributed to and are expected to continue to contribute to large declines in air toxics emissions, in spite of economic and population growth. In the absences of these programs, total emissions would be more than twice those projected in 2020.

Stationary source trends are different from mobile source trends in that the stationary source emissions begin to increase after 2010 whereas the mobile source trends show a continued decrease to 2020, when emissions begin to increase again. One reason for the continual decrease of the mobile source emissions through to the year 2020 is the nature of the mobile source programs and how they are phased in over time, where as the stationary source programs generally have a compliance date and all reductions are assumed to occur at that date.

As a surrogate for risk, we have explored the trends for toxicity-weighted emissions for both cancer and noncancer effects. Trends for toxicity-weighted emissions were similar to the total tonnage trends, though for stationary sources, lower reductions are achieved in the toxicity weighted emissions for cancer. This is because the stationary source reductions primarily result from the MACT program, which served to reduce tonnage of all HAPs; the residual risk program, which targets HAPs based on risk, is expected to reduce HAPs which pose the most risk. Because this program is relatively new, its impact has not been accounted for in these projections. For area sources, however, we find that the initial area source efforts of the early and mid 1990's have reduced some of the most toxics HAPs (perchloroethylene and hexavalent chromium). We find that fires is an important contributor to both cancer and noncancer risks.

Mobile source reductions appear to include the most toxics HAPs. This is because the mobile source emission reductions are generally similar across all mobile source organic HAPs, and it is these HAPs which comprise the bulk of the risk from mobile sources.

In the future we will continue to improve the inputs to these emission projections, not only by incorporating the ongoing control programs, which were not able to be included in this projection, but by also improving the base year and historical 1990 emission inventories and growth approaches. We will also explore other metrics to demonstrate the progress achieved by our programs.

DISCLAIMER

This paper has been reviewed in accordance with the U.S. EPA peer and administrative review policies and approved for presentation and publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for their use.

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KEYWORD

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