Projection of Future Year Emissions from a Base-Year Toxics Emission Inventory

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ABSTRACT

EPA has developed the Emission Modeling System for Hazardous Air Pollutants (EMS-HAP) to prepare hazardous air pollutant emissions for subsequent air quality modeling and to calculate future year emissions due to projected activity growth and reduction strategy scenarios. This paper focuses on EMS-HAP's capability to estimate future year emissions. EMS-HAP has the capability to project emissions due to activity growth based on Maximum Achievable Control Technology (MACT) category codes and/or the Standard Industrial Classification (SIC) codes. MACT-based and SIC-based growth can be applied on a national, state, or county-level basis. Based on user-specified options, EMS-HAP can implement emission reduction scenarios in several different manners. Emissions can be reduced broadly by MACT category, or more specifically by MACT, pollutant, SIC, and/or EPA Source Category Code (SCC). In addition, the user has the capability to reduce emissions at individual facilities. This paper presents the methodology employed by EMS-HAP for calculating future year emissions, describes the user inputs required, and discusses limitations of the system.

INTRODUCTION

The EPA's Office of Air Quality Planning and Standards (OAQPS) developed the Emission Modeling System for Hazardous Air Pollutants (EMS-HAP) to prepare toxic emission inventories for subsequent air quality dispersion modeling and to estimate future year toxic emissions. EMS-HAP version 1[1], was used to process the 1996 National Toxics Inventory (NTI) for the Assessment System for Population Exposure Nationwide (ASPEN)[2] dispersion model for the National Scale Air Toxics Assessment (NSATA).[3] Note that for this application, the projection capability of EMS-HAP was not used. Since the NSATA, the EMS-HAP Version 2 has been developed which adds the capability for EMS-HAP to prepare emissions for the Industrial Source Complex Short Term Version 3 (ISCST3)[4] model, and enhances the emission projection capabilities for estimating future-year toxics emissions. This paper details this enhanced emission projection capability.

Future year emissions are based on two factors: 1) projected activity growth, and 2) emission reduction strategy scenarios. Future year emissions can be obtained by applying either or both of these two factors. In EMS-HAP, projected activity growth is based on Maximum Achievable Control Technology (MACT) category codes, and/or 2-digit Standard Industrial Classification (SIC). MACT-based and SIC-based codes can be applied on a national, state, or county-level basis. The user has the option to grow emissions by MACT category only, SIC code only, or by both. Emission reductions are implemented by MACT category-based information and/or user-defined information. User-defined reductions can be applied based on information as broad as category name in the non-point source inventory and MACT category code in the point source inventory, to information as specific as a facility-level process for a pollutant. User-defined reductions can be applied instead-of, or in-addition-to, MACT-based reductions.

BODY

Overview of EMS-HAP

EMS-HAP uses SAS® software and is designed for application on UNIX® workstations. EMS-HAP can process two basic types of emission data: 1) point source data where emission sources are associated with specific geographic coordinates, and 2) county-level data (such as area and mobile source inventories). Note that the term "non-point" will be used to describe area source inventories so as not to conflict with the term "area source" which is also used to describe a type of stationary source based on its size as defined in the Clean Air Act (see NSATA website[3]).

Emission inventories must be SAS® software formatted prior to running EMS-HAP. The EMS-HAP User's Guide[1] provides detailed flowcharts through each EMS-HAP process. It is not the intent of this paper to detail the emission inventory-specific and dispersion model-specific properties of EMS-HAP, but rather, to detail the approach that EMS-HAP implements to obtain projected emissions. This approach is essentially independent of inventory (e.g., point versus non-point) and model type.

Processing emissions for ASPEN produces emission files with 8 annual emission rates -one for each 3-hour time block in an annual average day- at census tract centroids in latitude/longitude decimal degrees. Processing emissions for ISCST3 produces emission files with 288 annual emission rates [one for each hour of the day (24), season (4), and day of week type (weekdays, Saturday, and Sunday)] at UTM grid cells for gridded emissions, and distinct UTM coordinates for sources not spatially allocated. Regardless of which air quality 'switch' (ASPEN or ISCST3) is chosen, EMS-HAP performs the following basic functions:

- Converts location data to either UTM or latitude/longitude coordinates.
- Removes and/or defaults (ASPEN only) missing or out of range locations (ASPEN only).
- Quality assures point source inventory stack parameter data and defaults missing or erroneous data where possible.
- Groups and/or partitions individual pollutant species (e.g., groups lead oxide, lead nitrate into a lead group; partitions lead chromate into lead and chromium groups), and assigns the *NTI_HAP* variable (see Table 1).
- Retains only the desired pollutants and pollutant groups for modeling.
- Spatially allocates county-level emissions in the non-point and mobile source inventories.
- Temporally allocates emissions to dispersion-model-specific emission rates.
- Projects emissions to future years by implementing growth and emission reductions.
- Assigns source groupings based on the type of source
- Creates all emission-related input files for the dispersion model.

EMS-HAP requires ancillary input files to complete the above-mentioned tasks. EMS-HAP contains quality assurance (QA) procedures that provide the user with relevant summary statistics. For example, the module responsible for grouping and partitioning emissions provides pollutant-level and total emission summaries for pollutants retained, pollutants discarded, and pollutants not-matched to the relevant ancillary files; these emission summaries are provided before and after the pollutants are grouped and partitioned. The modules for spatial and temporal allocation and projection functions provide similar statistics.

EMS-HAP projects base year (baseline) emissions for the point source inventory. EMS-HAP can project base year emissions, or already-projected emissions for the non-point source inventory; this option allows the user to create various scenarios based on the same "grown only" inventory. EMS-HAP accomplishes this for the non-point inventory because it has the ability to pass a "grown only" inventory through the emission reduction procedures without having to rerun the growth (or spatial and temporal allocation, or pollutant grouping/partitioning) procedures of the model. Please note the following with regard to this capability:

1) It applies only to the non-point emission inventory. For a given geographic area or subset of pollutants, the non-point source inventory, with its associated spatially-allocated emissions, demands far more computation time during the projection modules than the point source inventory.
2) Growth and reduction factors are initialized to missing for projected inventories. The consequences of this will be discussed later in the paper.

Processing Future Year Emissions

EMS-HAP projects the emissions generated by EMS-HAP's temporal allocation function. The remainder of this paper will focus on the methodology used to project emissions. As mentioned above, the approach used to calculate projected emissions is largely independent of inventory (point versus non-point) and air dispersion model type.

Table 1 provides a list of key inventory variables EMS-HAP may use (depending on user options) for computing emissions for future years. Some of these variables are on the inventory input to EMS-HAP (e.g., *MACTCODE*) and others are assigned to the inventory by EMS-HAP (e.g., *NTI_HAP*) prior to the emission projection functions. EMS-HAP creates several additional variables in the projection modules; these variables will be discussed later in the paper. The use of the term 'source type' is important when deciding whether to apply certain emission reductions; 'major' and 'area' source types are specific stationary sources and their definitions are provided on the NSATA website[3].

After key variables (Table 1) are extracted from the temporally-allocated emission inventory, EMS-HAP executes the following user-determined, conditional sequence of projection functions:

1) Assigns MACT-based growth factors to the inventory
2) Assigns SIC-based growth factors to the inventory
3) Assigns "SIC-linked" growth factors based on either SCC (point) or category name (non-point) to the inventory
4) Assigns MACT-based reductions to the inventory
5) Assigns User-defined reductions to the inventory
6) Applies growth factors and reduction information to obtain a projected emission inventory.

These modules extract growth and/or emission reduction factors, then apply these factors to the input emissions to obtain future year, or, projected, emissions.

We expect that the user will not use EMS-HAP to project mobile sources. Mobile emission estimates usually involve running a mobile source emission model rather than multiplying base year emissions by a series of factors -which is basically what the projection modules do. Nonetheless, EMS-HAP can be used to project mobile emissions in a manner consistent with non-point sources if the user were to develop a set of growth and/or emission reduction factors.

Table 1. Emission Inventory Variables Used to Project Baseline Emissions.

Inventory Type	Variable	Description and Purpose for Retaining Variable
Point	NTI_HAP	Code identifying pollutant; used for reductions by MACT and user-defined reductions. Assigned by EMS-HAP based on pollutant code variable in the inventory.
	MACTCODE	MACT category code; used for MACT-based growth and reductions and user-defined reductions.
	SIC	SIC code for site; used for SIC-based growth and user-defined reductions.
	FIPS	5-digit state-county FIPS code.
	ACT_ID	Inventory FIPS concatenated with inventory SITE_ID; does not always identify a unique location because there may be sub-processes within the site that have different coordinates.
	SCC	SCC code; used to link many sources without SIC codes with SIC-based growth factors, and, used for user-defined reductions.
	CNTL_EFF	Baseline reduction strategy efficiency; used to account for reductions already applied to baseline inventory.
	SRC_TYPE	Description of the emission source at the site; MACT-based reductions are applied to either major ('major'), area ('area'), or both source types.
	TEMIS(N)	An array of 'N' temporally-allocated emissions, where 'N' is an array of either 8 for ASPEN-processed emissions, or 288 for ISCST3-processed emissions. Computed by EMS-HAP temporal processing of annual emissions.
Non-point	NTI_HAP	Code identifying pollutant; used for reductions by MACT and user-defined reductions. Assigned by EMS-HAP based on the pollutant code variable in the inventory.
	MACT	MACT category code; used for MACT-based growth and reductions and user-defined reductions.
	SIC	SIC code for site; used for SIC-based growth and user-defined reductions.
	CELL	A concatenation of 5-digit state-county FIPS code and either 6-digit census tract (ASPEN processing) or grid cell (ISCST3 processing); used only to extract state-county FIPS for user-defined reductions applied on a geographic scale.
	CATCODE	Links source to an emission category name; used to link many sources without SIC codes with SIC-based growth factors, and, used for user-defined reductions. Assigned by EMS-HAP based on category name.
	SRC_TYPE	Description of the emission source; MACT-based reductions are applied to either major ('major'), area ('area'), or both source types.
	TEMIS(N)	An array of 'N' temporally-allocated emissions, where 'N' is an array of either 8 for ASPEN-processed emissions, or 288 for ISCST3-processed emissions. Computed by EMS-HAP temporal processing of annual emissions. As previously discussed, these emissions may already be projected by a previous run of EMS-HAP for non-point sources.

Assignment and Application of Growth Factors

Growth factors are assigned on a national, state, or county-level basis by: MACT category only, SIC code only, or by both. Growth factors are not applied on the SCC level because they could potentially result in different growth rates for linked processes at a single facility. In the non-point inventory they can also be assigned based on category name using the SIC-link approach for those non-point categories which would not typically have an SIC code. This feature is described below. SIC-based growth is based on the first 2 digits of the SIC code. SIC-linked growth factors are obtained from the SIC-based growth factor file by linking pertinent inventory-specific variables to SIC codes:

- In the point source inventory, an ancillary file linking inventory 8-digit SCC codes to 4-digit SIC codes is used. Many SCC codes can be assigned to the same SIC code, but only one SIC code can be assigned to a given SCC code. Only the first 2 digits of the SCC-linked SIC code are used (along with state and county FIPS) to assign SIC-based growth factors.
- In the non-point source inventories, inventory category codes (see Table 1) are linked to category names, which in turn, are linked to 2-digit SIC codes or 4-character 'pseudo-SIC' codes for those non-point categories which would not typically have an SIC code. For example, the source category "Consumer Products Usage," found in the non-point source inventory, does not have a MACT category or SIC code associated with it. Therefore, we created a new 'pseudo-SIC' code called "POPN" to cross-reference the Consumer Products Usage source category and used a growth factor pertaining to population growth.

For either point or non-point inventories, once MACT-based growth factors are applied, they are never replaced with SIC-based growth factors. Similarly, SIC-based growth factors are never replaced with the 4-character SIC-linked growth factors.

Growth factors are supplied to EMS-HAP through two ancillary files: a MACT code-based growth factor file, and an SIC/pseudo-SIC–based growth factor file. These files contain factors that are specific to the base year and future year of interest in the reduction strategy analysis. Whether a growth factor is applied by MACT or SIC code, national growth factors will be replaced by state FIPS growth factors; similarly, county FIPS growth factors will replace state FIPS growth factors. Table 2 shows the state and county FIPS for national, state, and county-level growth factors.

Table 2. Regional Assignment of Growth Factors in the Growth Factor Files.

Assignment of Growth Factor	State FIPS	County FIPS
Nationally	'00'	'000'
State-wide	specific state FIPS code	'000'
County-wide	specific state FIPS code	specific county FIPS code

Emissions not assigned a MACT-based, SIC-based, or SIC-linked growth factor are assigned the default growth factor of one, ensuring that grown emissions are the same as input emissions. We stress the word 'input' emissions for the non-point source inventories, because the user may have already projected these data. Input emissions are always baseline emissions for the point source inventory. The following equation produces grown emissions from input emissions:

Equation (1) $\text{Grown emissions} = \text{Input emissions} \times \text{Growth factor}$

If growth is not selected by the user, the default growth factor of one is assigned and grown emissions are set equal to input emissions.

Assignment and Application of Emission Reduction Information

Emission reduction efficiency information can be assigned to the emission records by the MACT code, an important identifier in the National Toxics Inventory that reflects categories addressed by MACT standards and standards under Section 129 of the Clean Air Act. Emissions may also be reduced by applying user-defined, reduction strategies. The user supplies the emission reduction information based on MACT category and/or his/her own reduction strategy. Unlike 'MACT-based' reduction information, user-defined reduction information can account for geographically specific reduction strategies. User-defined reductions conditionally replace, or are added as additional reductions to, MACT-based reductions.

The discussion of reduction efficiency strategies is broken into three sections: 1) assignment of MACT-based reduction information, 2) assignment of user-defined reduction information, and, 3) combination and application of MACT-based and/or user-defined emission reductions.

<u>Assignment of MACT-based Reduction Information</u>

If chosen by the user, MACT-based reductions begin by applying a MACT category-level reduction information ancillary file, hereafter referred to as the 'MACT-gen' file. The MACT-gen file applies reductions to an entire MACT category or MACT process (if the process has a unique MACT code), but not to a particular facility (point inventory sources only) or pollutant emitted by the process.

MACT-based reductions can also be applied by specific MACT information based on MACT code and HAP (point and non-point inventories), and MACT code and HAP and/or 6- or 8-digit SCC code (point inventory only). The user provides this information in an ancillary file hereafter referred to as the 'MACT-spec' file. For the point source inventory, the MACT-spec file allows the user to assign different reduction information for specific processes within a MACT category and/or for specific HAPs that a MACT standard will affect. For non-point source inventories, records in the MACT-spec file with process-specific (SCC) information are ignored. Therefore, to apply pollutant-specific reductions to a MACT category in a non-point inventory, the user must include a record where the SCC fields are blank.

MACT-based reduction files (MACT-gen and MACT-spec) contain the following variables:

1) <u>Two reduction efficiencies</u>. Hereafter referred to as '*ExistEff*' and '*New_Eff*', the former efficiency represents the emission reduction to be applied to existing sources, while the latter represents the emission reduction to be applied to new sources. EMS-HAP has the flexibility to apply different reductions for new versus existing facilities because air pollution regulations often require higher emission reduction efficiencies for new facilities than for existing facilities. EMS-HAP assumes that all new sources are located at existing sources. This would occur, for example, if an existing source rebuilt or constructed an additional operation to the extent that the source, or some portion of the source, would be considered a new source.
2) <u>Percentage of emissions at existing sources that will come from new sources</u>. Hereafter referred to as '*NewRate*', EMS-HAP uses this information to apportion the emissions into new source versus existing source emissions for each inventory record. A value of 100% would mean that in the future year, the entire MACT category (or specific facility for point sources) rebuilt to the extent that the efficiency for new sources would apply. A value of 50% would signify half of the emissions were due to new sources at the existing facilities and the other half was from the existing part.
3) <u>Application reduction flag</u>. EMS-HAP uses this flag to determine whether or not to apply the reductions. This enables the user to keep the emission reduction information in an ancillary file, but not use that information for a particular run of EMS-HAP. To avoid reducing emissions twice, this flag should be set to false if the compliance year of the reduction (discussed later) is earlier than the inventory base year.
4) <u>Source reduction flag</u>. This flag determines to which source type (major, area, or both area and major) the reductions apply. For example, if a particular MACT standard affects only

major sources, then the user would set the source control flag to “M” and the reductions would only be applied to “major” source types in the inventory.

The variables ‘*ExistEff*’, ‘*New_Eff*’, and ‘*NewRate*’ comprise what are referred to as the “Primary Reduction Variables”. If the user decides to reduce emissions by MACT-based and user-defined reductions, and, the user decides to replace (with a user-defined reduction variable called ‘*Replace*’, discussed later) the MACT-based reductions with available user-defined reductions, then these three MACT reduction variables are not used in the calculations to reduce emissions. In short, the three “Primary Reduction Variables” assigned here with MACT-based reductions may be replaced by user-defined reductions. It is also possible to retain these MACT-based primary reduction variables and simply add “Additional Reduction Variables” with user-defined reductions.

The MACT-gen file also consists of the following variables in addition to those mentioned above:

5) Compliance year for the standard. EMS-HAP uses this information along with the projection year to determine if the standard will affect the emissions *for the entire year*. For example, if you are projecting to 2002, and the compliance year of the standard is 2002, then EMS-HAP will not apply the reduction for that standard to the inventory.
6) MACT bin. Used when the compliance year is unknown, this variable indicates the number of years between 1995 and the planned promulgation date of the MACT standard (e.g. 2, 4, 7, or 10 years).

In addition to the above-mentioned variables, the MACT-spec file also contains the following variables:

5) *NTI_HAP*. Pollutant ID (see Table 1).
6) 8-digit SCC. Used in point source inventory only, assigns process-specific reductions within a MACT category.
7) 6-digit SCC. Used in point source inventory only, assigns less detailed process-specific reductions within a MACT category.

Emission reduction efficiency information from the MACT-gen and MACT-spec is applied when the following criteria are satisfied:

1) The application reduction flag is true. Reduction information should not be applied (e.g., application reduction flag set to false) whenever the inventory *base year is greater than the compliance year* of the strategy; in which case, reductions are assumed already applied to the base year inventory.
2) The projection year is greater than the compliance year for the standard; or, if the compliance year is not provided, the projection year is greater than the MACT bin plus 1995. Note that the compliance year and MACT bin information is only contained in the MACT-gen file; the MACT-spec uses the compliance year and bin values from the MACT-gen.
3) The source reduction flag is in agreement with the inventory source type variable, *SRC_TYPE* (see Table 1). For example, area sources will be reduced if the source reduction flag is equal to ‘A’ (‘area’) or ‘B’ (both ‘area’ and ‘major’).

When both MACT-gen and MACT-spec reductions are selected, MACT-spec reductions will replace the MACT-gen reductions. Table 3 shows the assignment order for applying MACT reductions for the point and non-point inventories. If the user does not select MACT-spec reduction information, then only the MACT-gen reductions by MACT code will be applied.

Table 3. Assignment Order for Applying MACT Reduction Information.

Assignment Order	MACT code	HAP	6-digit SCC	8-digit SCC
1 (least specific information)	X			
2 (least specific MACT-spec information) (most specific non-point source information)	X	X		
3	X		X	
4	X			X
5	X	X	X	
6 (most specific, supercedes all others)	X	X		X

<u>Assignment of User-defined Reduction Information</u>

User-defined reductions can be applied instead of, or in addition to, MACT-based reductions. The user-defined reduction information file consists of many of the same variables (see previous section for details on how these variables function) as the MACT-gen file:

- <u>Two reduction efficiencies</u>: '*ExistEff*' and '*New_Eff*'
- <u>Percentage of emissions at existing sources that will come from new sources</u>: '*NewRate*'
- <u>Application reduction flag</u>
- <u>Source reduction flag</u>
- <u>Compliance year for the strategy</u>

The User-reduction file also contains the variable "*Replace*", which determines whether user-defined reductions replace (*Replace* = 'R'), or are applied in addition to (*Replace* = 'A') the MACT-based reductions. If user-defined reductions are applied in addition to MACT-based reductions (*Replace*= 'A'), then the variables '*ExistEff*', '*New_Eff*', and '*NewRate*' are assigned as "Additional Reduction Variables"; and, they are renamed '*AddXEff*', '*AddNEff*', and '*AddRate*', respectively. Table 4 demonstrates this point and also shows that the three reduction variables '*ExistEff*', '*New_Eff*', and '*NewRate*' are retained as "Primary Reduction Variables" for all other combinations: MACT-based only reductions, user-defined only reductions, and both reductions where '*Replace*' = 'R'.

Table 4. Assignment of MACT-based and User-defined Reduction Variables.

Emission Reduction Information	Value of REPLACE variable	Source of Reduction Variables Used to Project Emissions: Primary Reduction Variables	Source of Reduction Variables Used to Project Emissions: Additional Reduction Variables
MACT-based only	N/A	MACT-based	all set to zero
User-defined only	N/A	User-defined	all set to zero
Both MACT-based and User-defined	R	User-defined	all set to zero
	A	MACT-based	User-defined

Similar to the application of the MACT-based reductions, user-defined reduction information can only be assigned if the following criteria are satisfied:

1) The user-defined application reduction flag is true. Similar to the application of MACT-based reductions, this flag should be false if the inventory base year is greater than the compliance year of the strategy.
2) The projection year is greater than the user-defined compliance year.

3) The user-defined source reduction flag is in agreement with the inventory source type variable.

Emissions can be reduced through the user-defined reduction information in various inventory-specific combinations. Point source inventory user-defined reductions can be applied by various combinations (see Table 1 for variable descriptions):

- process (using MACT code, SCC, or SIC)
- facility (using the *ACT_ID* variable)
- pollutant (using the *NTI_HAP* variable)
- specific county or groups of specific counties (using the *CNTYCODE* variable)

The new variable, a 5-character code '*CNTYCODE*', introduced here is obtained from the user-specific ancillary text file that links the state-county FIPS to a county type code; this file is hereafter referred to as '*CNTY-USR*'. The variable *CNTYCODE* can identify general types of counties, such as urban or rural, that user-defined reductions are applied to, or, *CNTYCODE* can be associated with individual counties. The variable *CNTYCODE* in the *CNTY-USR* file needs to be customized by the user whenever an emission reduction strategy is tailored to a particular geographic region.

For the non-point inventory, user-defined reductions may be composed from combinations of the following:

- process (using non-point category -linked by *CATCODE* variable- or MACT code)
- pollutant (using the *NTI_HAP* variable)
- specific county or county types (using *CNTYCODE*)

The assignment order that user-defined reduction information is applied to the point and non-point source emission inventories is provided in Table 5 and Table 6, respectively.

Table 5. Specification of Point Source Inventory User-defined Emission Reduction Information and Assignment Order.

	Information Used to Specify Reduction Information					
Assignment Order	**Activity ID**	**MACT**	**SIC**	**SCC**	**HAP**	**County Code**
1 (least specific information)		X				
2		X				X
3		X			X	
4		X			X	X
5			X			
6			X			X
7			X		X	
8			X		X	X
9				X		
10				X		X
11				X	X	
12				X	X	X
13		X	X			
14		X	X			X
15		X	X		X	
16		X	X		X	X
17		X		X		
18		X		X		X
19		X		X	X	

Assignment Order	Information Used to Specify Reduction Information Activity ID	MACT	SIC	SCC	HAP	County Code
20		X		X	X	X
21			X	X		
22			X	X		X
23			X	X	X	
24			X	X	X	X
25		X	X	X		
26		X	X	X		X
27		X	X	X	X	
28		X	X	X	X	X
29	X					
30	X	X				
31	X			X		
32	X				X	
33	X	X			X	
34	X			X	X	
35	X	X		X		
36 (most specific information, supercedes all others)	X	X		X	X	

As seen in Table 5, point source inventory reductions can be applied to a distinct pollutant at a source as specific as a unique process (MACT and SCC) within a facility. For the 1996 NTI, sources at a particular facility (*ACT_ID*) have unique SIC codes, but may have different MACT and/or SCC codes.

Table 6. Specification of Non-point Source Inventory User-defined Emission Reduction Information and Assignment Order.

Assignment Order	Information Used to Specify Reduction Information Area and Mobile Source Category	MACT	HAP	County Code
1 (least specific information)	X			
2	X			X
3	X		X	
4	X		X	X
5		X		
6		X		X
7		X	X	
8 (most specific information, supercedes all others)		X	X	X

Combination and Application of MACT-based and/or User-defined Emission Reductions

EMS-HAP calculates projected emissions, from a grown emission inventory (Equation 1), by first applying primary reduction efficiencies for existing and new sources and the percentage of projected emissions attributed to the new sources (primary reduction variables *ExistEff*, *New_Eff*, and *NewRate*). EMS-HAP uses *NewRate* to apportion the grown emissions between the existing sources, using the factor (1-*NewRate*/100), and new sources, using the factor (*NewRate*/100). This allows EMS-HAP to apply the different reduction efficiencies to the emissions from existing source (*ExistEff*) and to the emissions from new sources (*New_Eff*).

EMS-HAP uses the baseline reduction efficiency (*CNTL_EFF*) included in the point source inventory to account for any existing reductions reflected in the original inventory emission values. If *CNTL_EFF* is less than the assigned emission reduction efficiency (*ExistEff* or *New_Eff*), EMS-HAP removes the baseline reduction prior to applying the emission reduction efficiency to the grown emissions.

When $ExistEff > CNTL\_EFF$:

Equation (2) $$P_{PE} = G \times \left[\left(1 - \frac{NewRate}{100}\right) \times \frac{\left(1 - \frac{ExistEff}{100}\right)}{\left(1 - \frac{CNTL\_EFF}{100}\right)} \right]$$

where

P_{PE}	=	grown and reduced emissions from existing sources
G	=	grown emissions (see Equation 1)
NewRate	=	primary percentage of projected emissions attributed to the new sources
ExistEff	=	primary reduction efficiency for existing sources
CNTL_EFF	=	inventory baseline reduction efficiency, present in point source inventory only

Similar to Equation 2, but when $New\_Eff > CNTL\_EFF$:

Equation (3) $$P_{PN} = G \times \left[\left(\frac{NewRate}{100}\right) \times \frac{\left(1 - \frac{New\_Eff}{100}\right)}{\left(1 - \frac{CNTL\_EFF}{100}\right)} \right]$$

where

P_{PN}	=	grown and reduced emissions from new sources
New_Eff	=	primary reduction efficiency for new sources

The variable *CNTL_EFF* is not in the non-point inventory; therefore the factor (1- *CNTL_EFF*/100) disappears in Equations 2 and 3 for non-point sources and no baseline reductions are applied.

In the point source inventory, if the baseline reduction efficiency is greater than the assigned emission reduction efficiency, we assume that the assigned emission reduction efficiencies will not affect the facility. Therefore, EMS-HAP doesn't apply the assigned emission reduction efficiency.

When $ExistEff \le CNTL\_EFF$:

Equation (4) $$P_{PE} = G \times \left(1 - \frac{NewRate}{100}\right)$$

Similar to Equation 4, but when $New\_Eff \le CNTL\_EFF$:

Equation (5) $$P_{PN} = G \times \left(\frac{NewRate}{100}\right)$$

Projected emissions using primary reduction information (P_P) are the sum of projected emissions from grown and reduced emissions from existing (P_{PE}) and new sources (P_{PN}):

Equation (6) $$P_P = P_{PE} + P_{PN}$$

The results of Equation 6 are the final projected emissions unless user-defined reductions are being applied in addition to (*Replace* = A) MACT-based reductions.

If user-defined reductions are being applied in addition to MACT-based reductions, additional reductions for existing and new sources are applied to the initially projected (result of Equation 6) emissions using a methodology similar to that in Equations 2 and 3; the only difference being that point source inventory additional reductions are not weighted by baseline control efficiencies. The additional reduction variables '*AddXEff*', '*AddNEff*', and '*AddRate*', created when user-defined reductions are applied in addition to (*Replace* flag = 'A') MACT-based reductions, are used to calculate additional reduction efficiencies.

Apply additional reduction information for existing sources:

Equation (7) $$P_{AE} = P_P \times \left[\left(1 - \frac{AddRate}{100}\right) \times \left(1 - \frac{AddXEff}{100}\right)\right]$$

where

P_{AE}	=	projected emissions from existing sources using primary emission reduction efficiencies
AddRate	=	additional percentage of projected emissions attributed to the new sources
AddXEff	=	additional reduction efficiency for existing sources

Similar to Equation 7, but for new sources:

Equation (8) $$P_{AN} = P_P \times \left[\left(\frac{AddRate}{100}\right) \times \left(1 - \frac{AddNEff}{100}\right)\right]$$

where

P_{AN}	=	projected emissions from new sources using primary emission reduction efficiencies
AddNEff	=	additional reduction efficiency for new sources

Final projected emissions, after applying additional reduction information (P_A), are the sum of additional projected emissions from existing (P_{AE}) and new sources (P_{AN}):

Equation (9) $P_A = P_{AE} + P_{AN}$

Final projected emissions equal the grown emissions (Equation 1) if no reductions are applied to the temporally-allocated grown emissions.

Example

This example demonstrates how growth and emission reduction parameters information are applied to the base year emissions for a few fictitious emission sources. Sample emission growth data for these fictitious sources are provided in Table 7. In addition, for this example, the following growth-related assumptions apply:

1) User selects MACT-based, SIC-based, and SIC-linked growth factors.
2) MACT-based growth factors are available for the fictitious inventory MACT codes specified.
3) SIC-based growth factor information is available for the fictitious inventory SIC codes specified.
4) SCC (if point source) or category name (if non-point source) are SIC-linked with a growth factor. (Note this is how emission source "D" got a growth factor).

Table 7. Fictitious Emission Sources and Projected Growth Information.

Source ID	Base Emissions [tpy]	MACT Code	MACT-based Growth Factor	SIC	SIC-based Growth Factor	Grown Emissions [tpy]
A	**10**	9999	1.60	99		**16**
B	**10**			99	1.20	**12**
C	**10**	9999	1.60	99		**16**
D	**10**				1.10	**11**

Sample emission reduction data for the grown (result of Table 7) fictitious sources are provided in Table 8. In addition, for this example, the following growth-related assumptions apply:

1) Source reduction flag types match source type and both MACT-based and user-defined reduction application flags are true.
2) MACT-based reduction information is available for the fictitious inventory MACT codes specified
3) User-defined reduction information has been assigned (by any of the methods depicted in Tables 5 and 6).
4) User-defined reduction information is identical for sources "A" and "C", except for the *Replace* flag.
5) If source is a point source, no baseline reduction is applied (*CNTL_EFF* = 0).
6) Percentage of emissions at existing sources that come from new sources is zero (variable *NewRate* and variable *AddRate* when *Replace* = A). This, along with the previous assumption, greatly simplifies reduction calculations (see Equation 2 and Equation 7).

Table 8. Fictitious Emission Sources and Projected Reduction Information.

Source ID	Grown Emissions [tpy]	MACT-based *ExistEff* (%)	User-defined *ExistEff* (%)	***Replace***	Primary Reduction Information (see Table 4)	Additional Reduction Information (see Table 4)	Final Projected Emissions [tpy]
A	**16**	50	70	R	70		**4.8**
B	**12**		95	N/A	95		**0.6**
C	**16**	50	70	A	50	70	**2.4**
D	**11**		0	N/A	0		**11**

The purpose of Tables 7 and 8 is to demonstrate how EMS-HAP progressively converts temporally-allocated base year emissions to final projected emissions. We chose both MACT-based and SIC-based (SIC code and SIC-linked to SCC or source category) growth. Notice in Table 7 that once MACT-based growth factors are assigned, SIC-based growth factors are not assigned because SIC-based growth factors never replace MACT-based growth factors. We also chose MACT-based and user-defined reductions, realizing that the *Replace* variable determines whether the source is reduced by user-defined only (Source A), or both MACT-based and user-defined reduction information (Source C).

Limitations

EMS-HAP is designed to process emission inventories with a particular format; if the variable names and relationships to their intended meanings in the emission and ancillary files are incorrect, EMS-HAP will not run successfully. The EMS-HAP User's Guide[1] describes how the emissions must be formatted. Once updated to include the newer projection approach discussed in this paper, the EMS-HAP User's Guide Version 2 will describe how the ancillary files must be formatted.

The results of the projection are greatly dependent on both the input inventory and the ancillary files containing the growth factors and emission reduction information. Much care needs to be taken in developing and quality assuring this information.

EMS-HAP is not designed to project mobile emission inventories because the projection modules rely primarily on MACT and SIC-level growth and reduction information. In contrast, mobile source inventories generally require an emission model that account for both the effects of numerous strategies (e.g., alternative fuels, vehicle maintenance programs) and temperatures on mobile source emission factors. Mobile source inventories are generally projected using modeled emission factors and Vehicle Miles Traveled (VMT) data; these data are generally on the Area and Mobile Systems (AMS) code level. Nonetheless, if AMS-level growth and/or reduction factors are available, EMS-HAP could use these to project future year emissions in a manner consistent with non-point source processing. The AMS-level growth factors could be linked to some new 'pseudo' SIC cross-reference codes; and/or reductions could be accomplished using user-defined reduction information at AMS category name-level.

EMS-HAP cannot implement facility-specific growth factors. The most specific growth factor information it can use is MACT or SIC-based growth factors specific to a single county. For example, if the user selects to grow based on MACT code, all facilities in the same county with the same MACT code will be assigned identical growth factors.

Another limitation deals with the pollutant-level of detail that projected emissions are estimated. Reductions are applied to pollutants *after* they are grouped and partitioned into the *NTI_HAP* variable; this has a couple of consequences when dealing with pollutant-level reduction scenarios:

- Metals are reduced the same for various particle and gas classes; that is, fine particles (particles with diameters less than 2.5 μm), coarse-particles (particles with diameters 2.5 μm – 10 μm), and gases (e.g. Mercury) are reduced by the same factor because they share the same *NTI_HAP* code.

- Constituents to Polycyclic Organic Matter (POM) are assigned to the same *NTI_HAP* code. POM is comprised of several pollutants such as 7-PAH and Naphthalene. As EMS-HAP is currently configured, reducing emissions by *NTI_HAP* will treat POM and its constituents the same even though the processes that create the individual components to POM may be subject to significantly different reduction strategies in the future.

While EMS-HAP has the capability to re-project non-point source inventory emissions, it should be done with the following in mind:

- This applies only to the non-point emission inventory because, for a given geographic area or subset of pollutants, the non-point source inventory, with its associated spatially-allocated emissions, demands far more computation time during the projection modules than the point source inventory. This is because once spatially allocated, the 1996 non-point source inventory is considerably larger than the point source inventory.
- Growth and reduction factors are initialized to missing for projected inventories. The hierarchy in which EMS-HAP assigns growth and reduction factors is based on whether or not a source already has a growth or reduction factor applied to it. For example, SIC-based growth factors will not replace MACT-based growth factors if the user chooses both MACT-based and SIC-based growth. However, if the user applies only MACT-based growth to a baseline inventory, and then re-projects the MACT-grown inventory with only SIC-based growth, emission sources with MACT-based growth already applied will again be grown by SIC-based growth. In short, when choosing to re-project an emission inventory through EMS-HAP's projection modules, it is important to remember that EMS-HAP only recognizes that the emission input was projected but retains no 'memory' of how the inventory was projected.

CONCLUSIONS

EMS-HAP, through the use of MACT-based, SIC-based, and user-defined information, has the ability to estimate future year emissions from a base-year toxics emission inventory such as the 1996 NTI. Future year emissions are obtained by applying growth factors and/or reductions based on reduction strategy scenarios. EMS-HAP, whether it is run for the ASPEN or ISCST3 dispersion model, applies growth and reduction information in the same manner. The projected emissions from EMS-HAP can be fed directly into the ASPEN or ISCST3 model to project ambient concentrations.

Given adequate inputs into the system, EMS-HAP could be used to analyze the MACT and other emission reduction strategies, and, along with risk characterization and other factors, help set priorities for future air toxics programs.

While EMS-HAP was designed primarily to project point and area sources, mobile sources can also be projected if the user supplies ancillary file information in the correct format.

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.

REFERENCES

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KEYWORD

EMS-HAP
projected emissions
reduction strategy
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