Developing a Consistent Methodology to Calculate VOC and HAP Evaporative Emissions for Stage I and Stage II Operations at Gasoline Service Stations for the 1999 NEI (DRAFT V2.0)

Glenn Tracy Johnson, PE
Pacific Environmental Services, Inc. (a MACTEC Company),
5001 South Miami Boulevard, Research Triangle Park, NC 27709
gtjohnson@mactec.com

ABSTRACT

Pacific Environmental Services, Inc. (PES) recently assisted Mr. Ron Ryan (US EPA) and the Emission Inventory and Improvement Program's (EIIP) Area Source Committee in analyzing the VOC emissions data provided in the 1999 National Emission Inventory (NEI) (draft v2.0) for Stage I and Stage II Operations at gasoline service stations. The analysis consisted of reviewing and summarizing the reported gasoline throughputs, emission factors, and emissions by State and Source Classification Codes (SCC's). The reported data was reviewed for completeness and accuracy using various quality assurance (QA) checks. In general, PES found that there were numerous data gaps and discrepancies in the NEI. Such data gaps and discrepancies included missing emission factors and gasoline throughputs, missing emission estimates for over 300 counties, an enormous discrepancy in the emission factors used for the various gasoline loading processes, and NEI emissions which were not attributed to SCC's representing specific processes such as "balanced submerged fill".

After the analysis of the 1999 NEI and with direction from Ron Ryan and the Emission Inventory Improvement Program's Area Source Committee, PES developed an independent and consistent methodology for estimating Stage I and Stage II VOC and toxic emissions (eight Hazardous Air Pollutants) on a State and county level for the entire U.S. This effort included obtaining 1999 gasoline consumption data from the U.S Department of Energy, developing a scheme to allocate state-level gasoline consumption to the county level, reviewing State and local air regulations for control requirements to account for rule penetration, using AP-42 methodologies to calculate Stage I evaporative emissions, and using EPA's MOBILE program to calculate Stage II evaporative emissions. PES' approach developed "gap-filling" data (such as emission factors and gasoline throughput) which can be inserted in the 1999 NEI. PES' calculated VOC emissions differed significantly for many counties and once approved by the States can be inserted into the NEI. Also, PES developed county-level HAP emission estimates for the various Stage I and Stage II loading operations.

INTRODUCTION

The draft 1999 NEI (draft v2.0) contains area and point source emission estimates for evaporative emissions resulting from the loading of gasoline at service stations. The emission estimates in the NEI are a mixture of data supplied by EPA as well as State and/or local air pollution

control agencies. As a result, it is probable that the service station emission estimates in the 1999 NEI are based on inconsistent methodologies and assumptions.

The project had a two-fold goal: to analyze the emissions estimates in the 1999 NEI from service station operations, and to develop a methodology for estimating Stage I (i.e., filling of underground storage tanks) and Stage II (i.e., vehicle refueling losses as well as spillage losses) service station emissions on a State and county level for the entire U.S. State- and county-level emissions comparisons were developed to show the differences between emissions listed in the 1999 NEI and emission estimates developed for this project. This paper summarizes PES' analysis of the 1999 Area and Point Source NEI for service stations that dispense gasoline. Also discussed is PES' approach for developing a consistent methodology for estimating VOC and HAP emissions from service station operations. Full documentation of the analysis and emission calculations is available on the EIIP website for review and comment. The results of this analysis have not been incorporated in the Draft version 3 of the NEI.

BODY

REVIEW OF THE 1999 AREA & POINT SOURCE NEI

Review of the Source Classification Code(s) (SCC)

PES reviewed SCC's associated with Stage I and Stage II operations at gasoline service stations as well as underground breathing and emptying losses at gasoline service stations. The 28 SCC's that PES reviewed are summarized in Table 1.

Review of Gasoline Throughput

PES reviewed the gasoline throughput data provided in the NEI. Although emissions were provided for most States, PES determined that gasoline throughput was available for only eight States in the Area Source NEI and only 15 States in the Point Source NEI.

PES compared the gasoline throughputs in the NEI to the 1999 throughputs reported by the U.S. Department of Energy (DOE) on their Website.[1] PES also compared the NEI gasoline throughputs for Stage I, Stage II, and underground storage tank (UST) breathing & emptying (B&E) losses. PES assumed that throughputs associated with each type of operation should be the same for a given state (i.e., the amount of gasoline unloaded into a service station's UST should be approximately equal to the amount of gasoline loaded into the vehicle from the UST). PES also reviewed the NEI for gasoline throughput units which are in different fields from the throughput value. Similar to gasoline throughput, few throughput units were listed in the NEI. For those listed, most were reported in units of 1,000 gallons ("E3GAL") or gallons ("GAL"). However, in the Area Source NEI, there were some apparently erroneous gasoline throughput units (e.g., "Thousand Tons" and "Million Cubic Feet").

We should note that gasoline throughput discrepancies do not necessarily indicate that the emissions values are incorrect, since many of the listed emissions are apparently not based on the listed throughputs.

Review of VOC Emission Factors

PES queried the NEI for VOC emission factors listed for the various service station operations. Similar to throughput, most of the fields for VOC emission factors did not contain a value. Generally, the emission factors listed in the Area Source NEI appear reasonable when compared to the average EPA factors (some variability is expected due to differences in gasoline RVP and temperature). However, we noted that some of the VOC emission factors listed in the Point Source NEI vary by several orders of magnitude when compared to the EPA average emission factors for the same SCC and appear to be in error. For example, the Point Source NEI lists emission factors for balanced/submerged fill as high as 2,000 lbs/10^3 gallons loaded. The AP-42 emission factor is 0.3 lbs/10^3 gallons loaded.[2]

Review of VOC Emissions

PES reviewed the NEI to determine the VOC emissions listed for the various service station operations. The combined VOC emissions from the Area and Point Source NEI are 814,791 tons. The majority (98.4%) of the emissions is listed in the Area Source NEI. Only 1.65% of the total emissions were listed in the Point Source NEI. PES conducted several quality assurance checks of the VOC emissions data and noted the following:

- There were no emission records for over 300 counties.
- Some States did not list emissions for both Stage I and Stage II operations.
- Some States did not list breathing and emptying emissions for underground storage tanks.
- Many States listed their emissions under generic SCC's (such as "Stage I: Total or Stage II: Total) and not more specific SCC's that denote if the emissions were from controlled or uncontrolled operations.
- Some States emissions were not allocated to the SCC's appropriate for their control level. For example in the Area Source NEI, one State listed emissions associated only with Stage I submerged loading operations (SCC 2501060051); however, the regulatory analysis indicated that the State also requires vapor balancing to which no emissions were allocated.

The review of the NEI and any noted discrepancies are discussed further in our summary report.[3]

METHODOLOGY FOR CALCULATING INDEPENDENT EMISSIONS ESTIMATES

General

After reviewing the NEI, PES developed a consistent methodology for estimating VOC and HAP emissions from Stage I and Stage II service station operations for comparison to values reported in the NEI. This effort included obtaining 1999 gasoline consumption data, allocating state-level gasoline consumption to the county level, reviewing state and local air regulations for Stage I and Stage II requirements, and developing county-specific emission estimates occurring from gasoline loading and unloading operations at service stations. The methodology used to calculate emissions from the following operations are discussed later in this paper:

- Uncontrolled Stage I (UST filling) loading operations (e.g., splash fill)
- Controlled Stage I loading operations (e.g., submerged fill and/or vapor balancing)
- Uncontrolled Stage II vehicle refueling operations (including spillage emissions)
- Controlled Stage II refueling operations (including spillage emissions)

- UST breathing and emptying operations.

Gasoline Throughput Data

For this effort, PES used 1999 state gasoline sales information provided on the U.S. Department of Energy's (DOE) Website.[1] The DOE Website provided monthly sales estimates ("1,000 gallons per day") for regular, mid-grade, and premium gasoline. To calculate monthly throughput estimates for each state, PES multiplied the daily estimates for each gasoline type for each month by the number of days in the month. The DOE estimates that approximately 131 billion gallons of gasoline were dispensed nationwide in 1999.

County Allocation of Gasoline Throughput

PES considered several options for allocating the State-level gasoline sales data to the county level. Such options included county population, vehicle miles traveled (VMT), and service station sales. Each of these options is discussed below.

County Population

One methodology considered for allocating State-level gasoline sales to the county level was based on county population. PES obtained 1999 county population estimates from the U.S. Bureau of Census.[4] Although a simple methodology, this methodology may overestimate gasoline consumption in areas that have high populations that use mass transit. The method may also not account for more rural areas where lower populations may travel greater distances and consume more gasoline per capita. Due to these limitations, county population was not selected as the general methodology for allocating State-level gasoline consumption to the county level.

Vehicle Miles Traveled (VMT)

Another methodology considered for allocating State-level gasoline sales to the county level was based on VMT. The Highway Performance Monitoring System (HPMS) produced by the Federal Highway Administration was investigated as a source of county-level VMT. It contains data (including VMT) on various types of public roads in the US. HPMS contains more detailed data on large arterial connector roads and area-wide summary information for urbanized, small urban, and rural areas. According to the Office of Highway Policy Information (OHPI), HPMS contains detailed VMT data for only major highways; however, total county-level VMT for all highway types was not available in HPMS.[5]

PES also reviewed the document entitled "Documentation for the Draft 1999 National Emissions Inventory for Criteria Air Pollutants – Onroad Sources" which describes the methodology used for developing criteria emission estimates for onroad vehicles (e.g., cars, trucks, motorcycles, etc.) using the MOBILE model.[6] For that study, county-level VMT was calculated based on interstate highway mileage for rural interstates. County-level VMT for other roadway types was based on county population. The VMT in MOBILE was consequently not used to allocate gasoline consumption because VMT for 5 of 12 of the roadway types was allocated to the county level based on population.

<u>Service Station Sales</u>

Another methodology considered for allocating State-level gasoline sales to the county level was based on service station sales. The U.S Census Bureau publishes a national Economic Census every 5 years. The last Economic Census was published for calendar year 1997 and provides detailed statistics for various sectors such as the Retail Trade Sector, which includes sales data from gasoline service stations. The Economic Census data for the gasoline service station subsector was available at the county level. Sales data for the gasoline service station sub sector was queried using the Census Bureau's *American FactFinder* at http://factfinder.census.gov.[7] It is important to note that the sales data included not only gasoline sales but also revenue from the sales of other fuels (e.g., diesel fuel and gasohol), sales from convenience store items, sales from automotive repair services, etc.

It is also important to note that the 1997 Census of Retail Trade did not disclose service station sales data for approximately 6 percent of the counties in the U.S. These counties had only a few service stations and the Census Bureau withheld their sales information to avoid disclosing sales data about individual service stations or companies. However, in most cases, complete sales data for each State was available at the State level, therefore PES subtracted the sum of the county-level sales data from the State-level sales data to determine the sales not reported for those few counties. The calculated undisclosed sales were allocated to the counties according to their population. This methodology was selected to allocate the State-level gasoline sales to the county level for most States.

The general consensus from the Area Source EIIP committee was that allocating gasoline consumption based on VMT was the preferred methodology. However county-level data was not readily available for all States. PES compared the two methodologies and found that they provided similar results. As a result, service station sales were used to allocate the State-level gasoline consumption to the county level except Delaware, Maryland, and the State of Washington who provided PES with county-level VMT data which was used to allocate their State-level gasoline data.

VOC Emission Factors/Methodology

<u>Stage I Loading Operations</u>

PES calculated uncontrolled loading loss emissions resulting from Stage I operations using the methodology outlined in Section 5.2 (dated January 1995) of EPA's AP-42.[2] Specifically, PES used the following equation:

$$\text{Equation (1)} \quad L_L = \frac{12.46 \times SPM}{T}$$

where:

L_L = Loading loss (uncontrolled), pounds per 1000 gallons (lb/10^3 gal) of liquid loaded

S = A saturation factor (see Table 2)

P = True Vapor pressure of liquid loaded, pounds per square inch absolute (psia)

M = Molecular weight of vapors, pounds per pound-mole (lb/lb-mole)

$$T \quad = \quad \text{Temperature of bulk liquid loaded, } °R \ (°F + 460)$$

The assumptions and values used for the variables in the above equation are discussed below.

Saturation Factor (S) - As discussed in EPA's AP-42, the saturation factor, S, represents the expelled vapors fractional approach to saturation and accounts for the variations observed in emission rates from the different unloading and loading methods. Section 5.2 of AP-42 provides suggested saturation factors for the various cargo tank loading methods.[2] The following saturation factors are listed in EPA's AP-42 and were used by PES to calculate loading loss emissions:

Note: There is not a SCC for splash loading with vapor balance. Consequently, PES assumed that all splash loading operations were uncontrolled (i.e., not equipped with vapor balancing). Also, PES assumed that where vapor balancing was required that submerged fill was also present (S=1.00).

True Vapor Pressure (P) - PES used the formula in Figure 7.1-14b (dated September 1997) of AP-42 to calculate the true vapor pressure of the gasoline.[8] The formula is as follows:

Equation (2)
$$P = \exp \left\{ \begin{array}{l} \left[\left[0.7553 - \left(\dfrac{413.0}{T+459.6}\right)\right]S^{0.5}\log_{10}(RVP) - \left[1.854 - \left(\dfrac{1,042}{T+459.6}\right)\right]S^{0.5} \right. \\ \left. + \left[\left(\dfrac{2,416}{T+459.6}\right) - 2.013\right]\log_{10}(RVP) - \left(\dfrac{8,742}{T+459.6}\right) + 15.64 \end{array} \right\}$$

where:

P = Stock true vapor pressure, in pounds per square inch absolute.
T = Stock temperature, in degrees Fahrenheit (assumed the same as bulk liquid temperature described below).
RVP = Reid vapor pressure, in pounds per square inch. PES used the same monthly RVP values that were used to calculate the 1999 onroad emission estimates using the MOBILE 6 model.)
S = Slope of the ASTM distillation curve at 10 percent evaporation, in degrees Fahrenheit per percent. PES assumed that S = 3.0 for gasoline per Figure 7.1-14a of AP-42)[8]

Molecular Weight (M) - For molecular weight, PES referred to Table 7.1-2 of AP-42.[8] As shown in the table, molecular weight of gasoline varies from 62-68 lb/lb-mole depending on the RVP of the gasoline. For the purposes of estimating molecular weight, PES used the same RVP values used to calculate 1999 onroad emission estimates using the MOBILE 6 model.

Bulk Liquid Temperature (T) - PES searched for recent data documenting bulk liquid temperatures in underground storage tanks. Texas provided temperature data for a few cities. Radian Corporation conducted a more comprehensive study in 1976 for the American Petroleum Institute.[10] The report from that study provided gasoline fuel temperature data collected from 56 service stations across the U.S. during all seasons of the year. With a few modifications, PES used this data as the basis for its Stage I calculations.

Stage I Control Efficiency - Stage I loading losses can be controlled using a vapor balance system (i.e., a hose that allows gasoline vapors from the UST to be displaced back to the cargo tank

during UST loading operations.). Most State regulations require that the vapor balancing system be 90-95% efficient in controlling this vapor transfer process. To account for emission from controlled Stage I loading, PES multiplied the uncontrolled loading losses calculated using the equation above by the overall reduction efficiency term:

Equation (3) $\left(1 - \dfrac{\textit{Control Efficiency}}{100}\right)$

where:

> *Control Efficiency* = the efficiency specified in the respective State regulation (typically 90 or 95%).

Stage II Loading Operations

PES' subcontractor, PECHAN, used the MOBILE 6 model to calculate refueling emission factors which represented refueling emissions occurring from both displacement and spillage. The general methodology used to calculate Stage II emissions using MOBILE is described below.

- Approximately 160 MOBILE input files were developed to represent controlled and uncontrolled refueling scenarios for all counties in the U.S. Corresponding output files were generated which provided monthly emission factors (grams VOC/mile) as well as fuel economy (miles per gallon) and VMT mix for 14 different gasoline vehicle types (e.g., LDGV, LDGT, and HDGV). The same monthly temperature and RVP data was included in the input files as was used to generate the 1999 onroad emission estimates.

- For each vehicle type, the monthly emission factor was multiplied by the fuel economy to convert the emission factor to "grams VOC/ gallon".

Equation (4)   grams VOC/mile x mile/gallon = grams VOC /gallon

- The VMT mix for the 14 vehicle types was used to calculate a single weighted monthly emission factor (grams VOC/gallon)

- The weighted emission factor was converted to lbs VOC/1000 gallons

Equation (5) grams VOC/gallon x lb/453.59 grams x   1/1000 = lbs VOC/1000 gallons

- The spillage emission factor (0.68 lbs VOC/1000 gallons) was subtracted from the weighted emission factor to calculate the controlled or uncontrolled Stage II displacement emission factor.

Note: MOBILE assumes a constant spillage factor of approximately 0.31 grams VOC/gallon that is equivalent to 0.68 lbs VOC/1000 gallons

- The monthly Stage II displacement and spillage emission factors (EF) were multiplied by the monthly county throughput (units of 1000 gallons) to estimate VOC emissions.

Equation (6) EF (lbs VOC/1000 gallons) x Throughput (1000 gallons) = Lbs VOC

Note: For the States with both uncontrolled and controlled Stage II operations, PES used controlled and uncontrolled emission factors and throughputs to calculate emissions.

UST Breathing & Emptying Operations

To estimate UST B&E emissions, PES evaluated two options. One option was to use the emission factor of 1.0 lb VOC/1000 gal loaded found in Section 5.2 of AP-42.[2] The other option was to assume that USTs have <u>no</u> breathing losses which is consistent with Section 7.1 of AP-42, Organic Liquid Storage Tanks (p. 7.1-11) and the U.S. EPA's TANKS software.[8,9]

For this analysis, PES opted to assume that UST B&E emissions are 1.0 lb/1000 gallons loaded. Using the AP-42 emission factor and the 1999 DOE throughput, nationwide breathing and emptying losses are approximately 66,500 tons of VOC compared to breathing losses reported in the Area Source NEI (47,000 tons of VOC) and in the Point Source NEI (1,300 tons of VOC).

Regulatory Review

PES reviewed State and local air regulations to identify those states which have Stage I and/or Stage II control requirements. To assist in its regulatory search, PES used a commercially available online product called ENFLEX.[11] ENFLEX' databases are updated at least monthly so PES had access to the most current air regulations for each State. The results of the regulatory review are summarized below.

Stage I

PES specifically searched for Stage I regulations to determine control level requirements (e.g., submerged loading and/or vapor balancing requirements), the date such regulations began, and the area and type of facility (e.g., minimum throughput size) requiring Stage I controls.

After researching the regulations, PES concluded that nine states do not have Stage I regulations (i.e., Alaska, Idaho, Iowa, Kansas, Mississippi, Nebraska, South Carolina, South Dakota, and Wyoming). As a result, PES assumed that counties in these states load gasoline using only the "splash fill" method and will use the saturation factor (S) of 1.45 in the calculation of emissions.

Most of the remaining States have statewide Stage I regulations that require submerged loading <u>and</u> vapor balancing. PES assumed an S factor of 1.0 for these states when calculating Stage I emissions. A few states required submerged loading but not vapor balancing (i.e., Arizona, Michigan, Minnesota, Montana, Nevada, North Dakota, and parts of Virginia. PES assumed an S factor of 0.6 for submerged loading operations, with no vapor balance. PES assumed that facilities which required submerged loading or vapor balancing (but not both) would opt for installing submerged loading only (S=0.6). Parts of California and Maryland specifically required vapor balancing but not submerged loading. In this situation, PES assumed that facilities have both submerged fill and vapor balance (S=1.0). Regarding the control efficiency of Stage I, if a State did not specify the control efficiency for Stage I, PES assumed a control efficiency of 90%. Otherwise, PES used the control efficiency cited in the regulations (e.g., 90% or 95%). Also, most states require Stage I controls for facilities that either exceed a throughput limit (e.g., 10,000 gallons per month) or a tank size limit (e.g., 250 gallons). The impact of such provisions on the emission calculations is discussed in the section entitled "Rule Penetration."

<u>Stage II</u>

Section 182(b) of the Clean Air Amendment (CAAA) of 1990 requires the installation of Stage II vapor recovery systems in areas that are designated as moderate, serious, severe, and extreme for ozone nonattainment. As a result, Stage II controls are less prevalent than Stage I controls. PES specifically searched Stage II regulations for data input needed to run the MOBILE model. The following information was gathered from the analysis of the Stage II regulations:

- Counties requiring Stage II controls (i.e., vapor balancing between the UST and vehicle fuel tank),

- Calendar year in which Stage II began,

- Number of years for phase-in of Stage II controls,

- Percent efficiency for light duty gasoline vehicles (LDGV) and light duty gasoline trucks (LDGT), and

- Percent efficiency for heavy duty gasoline vehicles (HDGV).

Note: LDGV represents passenger cars; LDGT represents pickup trucks, vans and other small trucks that have a gross vehicle weight of 0-8500 lbs; and HDGV represents all vehicles with a gross vehicle weight greater than 8,500 lbs, powered by gasoline.

Most States with Stage II provisions require 95% control. State regulations do not distinguish between control efficiencies for LDGV, LDGT, and HDGV. For the purposes of this effort, PES assumed the same Stage II control efficiency for HDGV as is assumed for LDGV.

From the regulatory search PES concluded that 23 states did not have Stage II requirements in 1999 (i.e., Alabama, Alaska, Arkansas, Colorado, Hawaii, Idaho, Iowa, Kansas, Michigan, Minnesota, Mississippi, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Oklahoma, South Carolina, South Dakota, Utah, West Virginia, and Wyoming). California, Connecticut, Delaware, Massachusetts, New Jersey, and Vermont require Stage II statewide. Washington D.C. also has Stage II requirements. The remaining states required Stage II in only counties or towns designated as ozone nonattainment areas or VOC control areas.

Similar to the Stage I regulations, most states' Stage II controls apply to facilities that exceed a throughput limit (e.g., 10,000 gallons per month). PES' methodology for estimating the impact of such provisions on the emission calculations is discussed in the next section entitled "Rule Penetration."

Rule Penetration

Rule penetration can be described as the percent of sources covered by a rule, or in this case, the percent of gasoline throughput covered by a rule. As stated earlier, most State's Stage I regulations apply to facilities exceeding a specified throughput or tank size threshold. For example in Alabama, submerged loading and vapor balancing only apply to facilities in the counties listed whose monthly throughput exceeds 4,000 gallons per month <u>and</u> for tanks greater than 3,000 gallons. Stage II regulations have similar throughput and/or tank size applicability thresholds. For example, Delaware requires Stage II statewide, but only at facilities whose gasoline throughput exceeds 10,000

gallons per month. As a result, it is reasonable to assume that facilities that do not exceed throughput limit do not have Stage II controls.

To account for the effects of the throughput thresholds, PES used published information regarding the size (or consumption) distribution of retail service stations (see Table 3).[12] If a State has a 10,000 gallon per month threshold, PES estimates that approximately 91.3% of the throughput is affected by the regulation. One would expect that less throughput would be affected by States' with a higher applicability threshold. For example, Texas' Stage II regulations only apply to facilities whose throughput is greater than 100,000 gallons per month. As shown in Table 3, the amount of gasoline throughput affected by Texas' Stage II regulations is 18.8 percent.

Note: PES was not able to obtain information regarding tank size distribution; therefore the rule penetration for regulations with tank size thresholds (e.g., greater than 250 gallons) was ignored (i.e., PES assumed 100% rule penetration).

To estimate the portion of controlled fuel, PES multiplied the total gasoline throughput by the percentage of controlled throughput listed in Table 3. Uncontrolled gasoline throughput was calculated by taking the difference in total gasoline throughput and controlled gasoline throughput.

Hazardous Air Pollutant (HAP) Profiles

PES estimated HAP emissions from Stage I and Stage II operations based on average HAP contents for normal, reformulated and oxygenated gasoline. The average HAP contents for these types of gasoline are listed in Table 4.[13] The HAP content is expressed as a ratio by weight of HAP to total VOC. PES multiplied the HAP ratios by the estimated VOC emissions to obtain the estimated HAP emitted from Stage I and Stage II operations. The three types of gasoline are discussed below.

Normal Gasoline – As shown in Table 4, normal gasoline contains seven HAPs. PES used the normal HAP-to-VOC ratio for all Stage I and Stage II emissions generated in counties not using reformulated and/or oxygenated fuels.

Reformulated Gasoline (RFG) – The Clean Air Act Amendments (CAAA) requires RFG in the most severe ozone non-attainment areas of the country. However, other areas with ozone problems have voluntarily opted into the RFG program. EPA's Office of Transportation and Air Quality (OTAQ) provides a list of areas participating in the federal reformulated gasoline program on its Website (http://www.epa.gov/oms/regs/fuels/rfg/rfgarea.pdf). The Website lists 160 counties from 16 states and the District of Columbia as having RFG. PES used RFG profiles for those counties to calculate their HAP emissions.

Oxygenated Gasoline – The 1990 CAAA also requires an oxygenated fuel program for areas exceeding the federal carbon monoxide (CO) air quality standards. The oxygenated gasoline program requires that gasoline dispensed in CO nonattainment areas in the winter months meet a minimum oxygen content (2.7% by weight) to reduce the CO emissions from vehicles. 59 counties were modeled using the HAP-to-VOC ratios for oxygenated gasoline. PES also took into account the MTBE and ethanol market shares for those counties and the winter months when oxygenated gasoline is used.

Calculations

VOC Calculations

A Microsoft® Excel Workbook was developed using the procedures and assumptions in this document to calculate nationwide VOC emissions resulting from Stage I and Stage II service station operations at both the State and county level. Twelve spreadsheets (one for each month) were developed using monthly temperature, RVP, and gasoline throughput data. Each spreadsheet contains all VOC Stage I and Stage II emission estimates for all counties in the U.S. as well a summation of county emissions by State. An additional spreadsheet was added to calculate annual emission estimates by summing the monthly emission estimates.

HAP Calculations

PES developed a Microsoft® Access database to calculate HAP emissions. The database contains a VOC emissions table that contains monthly VOC emissions estimates by county, month, and process as well as the MTBE share (developed from the Stage I VOC Microsoft® Excel workbook. The database also contains the HAP profiles for each of the fuel types. A query was developed which multiplies the VOC emissions by the appropriate HAP profile (i.e., normal, reformulated, or oxygenated gasoline). Except for MTBE, all HAP calculations are simply a multiplication of the VOC emissions by the HAP weight percentage for each pollutant. MTBE emissions are calculated by multiplying the VOC emissions by the MTBE weight percentage and by the MTBE market share.

Results Compared to NEI

PES' calculated a nationwide value of 829,521 tons of VOC emissions compared to the NEI nationwide value of 814,791 tons of VOC. Although the overall values are close, PES compared the its calculated county-level emissions to those in the NEI. In most cases there was significant deviation in the PES and NEI estimates. For example when comparing PES' and the NEI's county-level estimates only about 10 percent of the emission estimates agreed closely (i.e., within 10 percent deviation).

Using the HAP profile in Table 4, PES calculated HAP emissions resulting from eight HAP pollutants. The nationwide emission estimates generated using PES' approach is as follows:

- 2,2,4 Trimethylpentane – 6,530 tons
- Benzene – 6,990 tons
- Ethyl benzene – 830 tons
- Hexane – 13,060 tons
- MTBE – 5,830 tons
- POM – 4,150 tons
- Toluene - 10,570 tons
- Xylene – 4,040 tons

CONCLUSIONS

Based on the analysis of the Area and Point Source NEI for gasoline service stations and the results of the independent calculation of emissions, PES concluded the following:

- There are considerable data gaps (throughput, emissions factors, and emission values in both the Area and Point Source NEIs. Also some data (i.e., emission factors) are wrong. The approach used in this paper generates site-specific information which can be added to the NEI.

- The State and county-level NEI emission estimates are not consistent with the level of Stage I and Stage II control.

- Allocating emissions to the appropriate level of control provides more meaningful information to the end-users of the information.

- The independent calculation of the nationwide VOC emissions from service station operations produced county-level emissions significantly different from the NEI.

- An independent calculation of the nationwide VOC and HAP emissions from service station operations achieves consistency in methodology and enables future NEI updates (e.g., for 2002) to be calculated both faster and easier.

BIBLIOGRAPHY

[1] Department of Energy Website. 1999 Gasoline Consumption. http://www.eia.doe.gov/emeu/states/_states.html.

[2] "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources", Section 5.2 Transportation and Marketing of Petroleum Liquids. January 1995.

[3] "Draft Summary of the Analysis of the Emissions Reported in the 1999 NEI for Stage I and Stage II Operations at Gasoline Service Stations (draft v2.0), Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC by Pacific Environmental Service, Inc, RTP, NC. September 2002.

[4] Bureau of the Census Website. 1999 County Population Data. (http://eire.census.gov/popest/archives/county/co_99_1.php).

[5] Johnson, G.T., 2002. Office of Highway Policy Information, *personal communication.*

[6] "Documentation for the Draft 1999 National Emissions Inventory for Criteria Air Pollutants – Onroad Sources", Prepared for the U.S. Environmental Protection Agency, RTP, NC by E.H. Pechan and Associates, Inc, Springfield, VA. October 2001.

[7] American FactFinder Website. Economic Census. 1997 Retail Trade Data for Gasoline Service Stations. (http://factfinder.census.gov.)

[8] "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources," Section 7.1, Organic Liquid Storage Tanks, Figure 7.1-14b of AP-42. September 1997.

[9] TANKS, Storage Tank Emissions Calculation Software, USEPA.

[10] McNally, A.M., et al, "Summary and Analysis of Data from Gasoline Temperature Survey conducted at Service Station by the American Petroleum Institute", Prepared for the American Petroleum Institute, Washington, DC by Radian Corporation, Austin, TX. November 1976.

[11] Enflex (http://www.enflex.com).

[12] "Technical Guidance – Stage II Vapor Recovery Systems for Control of Vehicle Refueling Emissions at Gasoline Dispensing Facilities, Volume I: Chapters", U.S. Environmental Protection Agency, Research Triangle Park, NC, November 1991, EPA-450/3-91-022a, Table 2-10.

[13] "Documentation for the 1999 Base Year Nonpoint Source National Emission Inventory for Hazardous Air Pollutants", Prepared for the U.S. Environmental Protection Agency, RTP, NC by the Eastern Research Group, Morrisville, NC. September 2001.

TABLES

Table 1. List of SCC's Used in Analyzing the 1999 Point and Area Source Inventory for Service Stations

Point Source SCC	SCC Description
40600301	Gasoline Retail Ops - Stage I/Splash fill
40600302	Gasoline Retail Ops - Stage I/Submerged filling w/o controls
40600305	Gasoline Retail Ops - Stage I/Unloading
40600306	Gasoline Retail Ops - Stage I/Balanced Submerged Fill
40600307	Gasoline Retail Ops - Stage I/UST Breathing & Emptying
40600399	Gasoline Retail Ops - Stage I/Not Classified
40600401	Filling Vehicle Gas Tanks - Stage II/Vapor Loss w/o controls (pumped)
40600402	Filling Vehicle Gas Tanks - Stage II/Liquid Loss w/o controls
40600403	Filling Vehicle Gas Tanks - Stage II/Vapor Loss w/o controls (transferred)
40600499	Filling Vehicle Gas Tanks - Stage II/Not Classified
40600601	Consumer (Corporate) Fleet Refueling - Stage II/Vapor Loss w/o controls
40600602	Consumer (Corporate) Fleet Refueling - Stage II/Liquid Loss w/o controls
40600603	Consumer (Corporate) Fleet Refueling - Stage II/Vapor Loss w/ controls
40600701	Consumer (Corporate) Fleet Refueling - Stage I/Splash Filling
40600702	Consumer (Corporate) Fleet Refueling - Stage I/Submerged Filling w/o controls
40600706	Consumer (Corporate) Fleet Refueling - Stage I/Balanced Submerged fill
40600707	Consumer (Corporate) Fleet Refueling - Stage I/UST Breathing & Emptying
Area Source SCC	**SCC Description**
2501060000	Gasoline Service Stations/Total: All Gasoline/All Processes
2501060050	Gasoline Service Stations/Stage 1: Total
2501060051	Gasoline Service Stations/Stage 1: Submerged Filling
2501060052	Gasoline Service Stations/Stage 1: Splash Filling
2501060053	Gasoline Service Stations/Stage 1: Balanced Submerged Filling
2501060100	Gasoline Service Stations/Stage 2: Total
2501060101	Gasoline Service Stations/Stage 2: Displacement Loss/Uncontrolled
2501060102	Gasoline Service Stations/Stage 2: Displacement Loss/Controlled
2501060103	Gasoline Service Stations/Stage 2: Spillage
2501060200	Gasoline Service Stations/Underground Tank: Total
2501060201	Gasoline Service Stations/Underground Tank: Breathing and Emptying

Table 2. Gasoline Saturation Factors for Storage Tank Loading

Mode of Operation	S Factor
Submerged loading with no vapor balance	0.6
Submerged loading with vapor balance	1.00
Splash loading no vapor balance	1.45

Table 3. Nationwide Service Station Consumption Distribution

Facility Throughput Range (gallons/Month)	Percent Consumption
0 – 5,999	4.7
6,000 – 9,999	4.1
10,000 – 24,999	17.8
25,000 – 49,999	27.5
50,000 – 99,999	27.2
> 100,000	18.8
Total[a]	100

[a]   Total may not sum due to rounding

Table 4. HAP Vapor Profile for Various Gasoline Types
(Weight % of Total VOC)

Pollutant	Normal	Reformulated		Winter-Oxygenated	
		W/MTBE	W/Ethanol	W/MTBE	W/Ethanol
2,2,4-Trimethylpentane	0.8	0.7	0.7	0.7	0.7
Benzene	0.9	0.4	0.4	0.7	0.7
Ethyl benzene	0.1	0.1	0.1	0.1	0.1
Hexane	1.6	1.4	1.4	1.4	1.4
MTBE	0	8.7	0	11.9	0
POM as 16-PAH	0.5	0.5	0.5	0.5	0.5
Toluene	1.3	1.1	1.1	1.1	1.1
Xylene	0.5	0.4	0.4	0.4	0.4