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Memo

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To: Ron Methier, SESARM

From: Kirstin B. Thesing

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Subject: Growth and Control Factor Development for Aircraft, Commercial Marine Vessels, and Locomotives

Comments:

This memorandum describes how TranSystems|Pechan estimated growth factors for aircraft, as well as growth and control factors for commercial marine vessels and locomotives. These growth and control factors can be used by SEMAP State and local agencies to prepare forecast year inventories for years 2017-2025 from a 2007 base year.

1. Aircraft

Aircraft emission estimates were developed for the following SCCs for the 2007 SEMAP base year inventory.

Description	SCC
Military Aircraft	2275001000
Commercial Aircraft	2275020000
General Aviation - Piston	2275050011
General Aviation - Turbine	2275050012
Air Taxi - Piston	2275060011
Air Taxi - Turbine	2275060012
Auxiliary Power Unit (APU)	2275070000
4-Stroke Gasoline Ground Support Equipment (GSE)	2265008005
LPG GSE	2267008005
CNG GSE	2268008005
Diesel GSE	2270008005

Growth factors for all aircraft engine and airport-related SCCs were based on state-level landing and take-off operation (LTO) projections available from the Federal Aviation Administration's Terminal Area Forecasts (TAF) (FAA, 2010). Forecasts of LTOs are available for commercial, military, general aviation and air taxi operations (both itinerant and local). Commercial aircraft LTO data were used to develop growth factors for the APU and ground support equipment (GSE) categories. All growth factors were calculated relative to 2007 LTO data. Growth rates for military aircraft were held constant at 2007 levels. Forecasts of LTOs for individual airports/facilities in the TAF assigned to counties were compiled by aircraft type for the select forecast year, and summed to the county level. Since all airports and their associated LTOs in the TAF could not be readily assigned to counties, State average growth factors were also calculated.

Traditionally, control factors have not been applied to aircraft for criteria pollutant forecasts. Quantitative information on reductions has not been available, and the reductions from these standards are believed to be minimal. EPA's Office of Transportation and Air Quality has an active project that is designed to help them better understand the impact of ICAO standards on commercial aircraft NO_x emission inventories. TranSystems|Pechan contacted EPA and learned that year-specific NO_x control factors accounting for rule penetration into the domestic aircraft fleet will be forthcoming, but are not yet available (Manning, 2011). As such, no controls were developed and applied to the aircraft engine category forecasts.

2. Commercial Marine Vessels

For the purpose of applying growth and controls for commercial marine vessels (CMVs), it was assumed that Category 1 and 2 engines typically use distillate fuels, while Category 3 engines primarily use residual blends. As such, Category 1 & 2 growth and control factors were applied to diesel in-port and underway SCCs (2280002100 and 2280002200), and Category 3 growth factors and reductions were applied to residual in-port and underway SCCs (2280003100 and 2280003200).

TranSystems|Pechan developed growth factors for residual CMVs using average annual growth rates by region developed by EPA for the RIA to support their Category 3 engine rulemaking (EPA, 2009a). Regional growth rates are available for designated states in the East Coast region, as well as the Gulf Coast Region. These same growth rates were used to estimate 2007 SEMAP emissions from the available 2008 NEI emission estimates for residual CMV emission estimates (Pechan, 2010).

For diesel engine CMV emissions, TranSystems|Pechan calculated growth factors based on fuel consumption forecasts published by the EIA. Table 67 of EIA's *Annual Energy Outlook, 2010* provides national-level forecasts of distillate oil (diesel) energy consumption (in trillion Btu) by domestic and international shipping sectors for years out to 2035 (EIA, 2010).

In 2009, EPA promulgated new emission standards for certain categories of diesel engines used in CMVs. TranSystems|Pechan developed CMV control factors using information from EPA's regulatory impact analyses (RIA) for these emission standards (EPA, 2008; EPA, 2009a).

Control factors for Category 1 & 2 engines were developed based on emission reductions calculated from national base case and control case inventories developed for the years 2002 through 2040 (EPA, 2008). These control factors account for both the level of control required by the standard (i.e., control efficiency) as well as the measure of rule penetration (i.e., what fraction of the fleet is meeting the specific level of control). TranSystems|Pechan estimated emission reductions and control factors for the chosen forecast year relative to any reductions expected to occur in the 2007 base year. Emission reductions were modeled for NO_x, SO_2, PM-10, PM-2.5, and VOC for Category 1 & 2 engines.

Control factors for Category 3 engines were developed from EPA regional base case and control case inventories. EPA's RIA for Category 3 engines includes base and control case inventories for select years out to 2030 (EPA, 2009a). Region-specific control factors were developed for the selected forecast year based on EPA's inventories for the East Coast and Gulf Coast regions of the U.S. Using EPA designations, SESARM States/counties were assigned to the East Coast or Gulf Coast region. Emission reductions were modeled for NO_x, SO_2, PM-10, and PM-2.5 for Category 3 engines.

3. Locomotives

Base year emissions for locomotives are reported for the following SCCs:

- 2285002006 – Diesel Class I Line Haul
- 2285002007 – Diesel Class II/III Line Haul
- 2285002008 – Diesel Passenger (Amtrak)
- 2285002009 – Diesel Commuter
- 2285002010 – Diesel Switchyard Locomotives

For Class I and Class II/III line haul and diesel switchyard operations, TranSystems|Pechan calculated growth factors based on freight rail sector fuel consumption forecasts, as published by the EIA. Table 67 of EIA's *Annual Energy Outlook, 2010* provides national-level forecasts of freight rail distillate oil (diesel) consumption (in trillion Btu) out to 2035 (EIA, 2010). For passenger and commuter rail, growth factors were developed from national forecasts of intercity rail diesel consumption, and commuter rail diesel consumption, available from Table 46 of the *Annual Energy Outlook, 2010* (EIA, 2010).

Similar to CMVs, diesel locomotive engines are subject to revised Federal Tier 0, Tier 1, and Tier 2 standards, as well as new Tier 3 and 4 standards. TranSystems|Pechan developed control factors for diesel-powered locomotive engine emissions based on EPA's locomotive engine RIA and associated emission factor guidance (EPA, 2008; EPA, 2009b). TranSystems|Pechan compiled fleet-average emission factors published by EPA for 2007 and the chosen forecast year, and calculated the incremental reductions expected over this time period. Future year emission factors are available for Large Class I Line Haul, Small Class II/III Line Haul, Switchyard, and Passenger/Commuter operations. Reductions were modeled for NO_x, PM-10, PM-2.5, VOC, as well as SO_2.

4. File Formats

To transmit the relevant nonroad growth and control information, we prepared the following Excel files. Descriptions of their content are also included.

Nonroad Growth Factor Summary.xlsx – This file contains growth factors by state and source category code (SCC) for each forecast year relative to 2007 (Columns K through S – highlighted in green). A growth factor code and growth factor code description are also provided to indicate which set of data were used to develop each growth factor. County-level growth factors were developed for some counties for residual CMV (to reflect available regional growth rates), and for aircraft where airports and their associated LTOs from the TAF could be matched to counties. The geographic resolution of the growth factors is indicated in Column J, "Geography." The state or county to which the growth factor applies is listed under Column A, "FIPS." State or local agencies should first match nonroad category growth factors by SCC and FIPS county, and where there is no match at the county level, the state-level GF should be used.

SEMAP Rail and CMV Control Factors.xlsx – This file contains two sheets - "Locomotive Controls," and "CMV Controls." In both sheets, control factors (CF) by state or county and SCC are provided for each forecast year relative to 2007 (highlighted in yellow and labeled as 2017 CF, 2018 CF, etc.) Values for control efficiency (CE), rule penetration (RP), and rule effectiveness (RE), that comprise the overall control factor, are also included. Control efficiency for each SCC was determined by compiling the control efficiency of the most stringent Tier associated with a standard, relative to the baseline control. Rule effectiveness was always assumed to be 100%. Rule penetration was then estimated based on the CE, RE, and final CF value. All values are expressed as a percent. In a few cases, county-level control factors were developed (e.g., for residual CMV to reflect regional growth rates in Florida). The state or county to which the control factor applies is listed under Column A, "FIPS." Similar to the growth factors, State or local agencies should first match nonroad control factors by SCC and county, and where there is no match at the county level, the state-level GF should be applied.

5. References

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