Technical Support Document (TSD): Preparation of Emissions Inventories for the 2016v3 North American Emissions Modeling Platform

EPA-454/B-23-001
January 2023

Technical Support Document (TSD): Preparation of Emissions Inventories for the 2016v3 North American Emissions Modeling Platform

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Assessment Division
Research Triangle Park, NC

Authors:
Alison Eyth (EPA/OAR)
Jeff Vukovich (EPA/OAR)
Caroline Farkas (EPA/OAR)
Janice Godfrey (EPA/OAR)
Karl Seltzer (EPA/OAR)

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

Acronyms

AADT	Annual average daily traffic
AE6	CMAQ Aerosol Module, version 6, introduced in CMAQ v5.0
AEO	Annual Energy Outlook
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AIS	Automated Identification System
APU	Auxiliary power unit
BEIS	Biogenic Emissions Inventory System
BELD	Biogenic Emissions Land use Database
BenMAP	Benefits Mapping and Analysis Program
BPS	Bulk Plant Storage
BTP	Bulk Terminal (Plant) to Pump
C1C2	Category 1 and 2 commercial marine vessels
C3	Category 3 (commercial marine vessels)
CAMD	EPA's Clean Air Markets Division
CAMx	Comprehensive Air Quality Model with Extensions
CAP	Criteria Air Pollutant
CARB	California Air Resources Board
CB05	Carbon Bond 2005 chemical mechanism
CB6	Version 6 of the Carbon Bond mechanism
CBM	Coal-bed methane
CDB	County database (input to MOVES model)
CEMS	Continuous Emissions Monitoring System
CISWI	Commercial and Industrial Solid Waste Incinerators
CMAQ	Community Multiscale Air Quality
CMV	Commercial Marine Vessel
CNG	Compressed natural gas
CO	Carbon monoxide
CONUS	Continental United States
CoST	Control Strategy Tool
CRC	Coordinating Research Council
CSAPR	Cross-State Air Pollution Rule
E0, E10, E85	0%, 10% and 85% Ethanol blend gasoline, respectively
ECA	Emissions Control Area
ECCC	Environment and Climate Change Canada
EF	Emission Factor
EGU	Electric Generating Units
EIA	Energy Information Administration
EIS	Emissions Inventory System
EPA	Environmental Protection Agency
EMFAC	EMission FACtor (California's onroad mobile model)
EPIC	Environmental Policy Integrated Climate modeling system
FAA	Federal Aviation Administration
FCCS	Fuel Characteristic Classification System
FEST-C	Fertilizer Emission Scenario Tool for CMAQ
FF10	Flat File 2010
FINN	Fire Inventory from the National Center for Atmospheric Research

FIPS	Federal Information Processing Standards
FHWA	Federal Highway Administration
HAP	Hazardous Air Pollutant
HMS	Hazard Mapping System
HPMS	Highway Performance Monitoring System
ICI	Industrial/Commercial/Institutional (boilers and process heaters)
I/M	Inspection and Maintenance
IMO	International Marine Organization
IPM	Integrated Planning Model
LADCO	Lake Michigan Air Directors Consortium
LDV	Light-Duty Vehicle
LPG	Liquified Petroleum Gas
MACT	Maximum Achievable Control Technology
MARAMA	Mid-Atlantic Regional Air Management Association
MATS	Mercury and Air Toxics Standards
MCIP	Meteorology-Chemistry Interface Processor
MMS	Minerals Management Service (now known as the Bureau of Energy Management, Regulation and Enforcement (BOEMRE)
MOVES	Motor Vehicle Emissions Simulator
MSA	Metropolitan Statistical Area
MTBE	Methyl tert-butyl ether
MWC	Municipal waste combustor
MY	Model year
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Classification System
NBAFM	Naphthalene, Benzene, Acetaldehyde, Formaldehyde and Methanol
NCAR	National Center for Atmospheric Research
NEEDS	National Electric Energy Database System
NEI	National Emission Inventory
NESCAUM	Northeast States for Coordinated Air Use Management
NH_3	Ammonia
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NONROAD	OTAQ's model for estimation of nonroad mobile emissions
NO_X	Nitrogen oxides
NSPS	New Source Performance Standards
OHH	Outdoor Hydronic Heater
ONI	Off network idling
OTAQ	EPA's Office of Transportation and Air Quality
ORIS	Office of Regulatory Information System
ORD	EPA's Office of Research and Development
OSAT	Ozone Source Apportionment Technology
PFC	Portable Fuel Container
$PM_{2.5}$	Particulate matter less than or equal to 2.5 microns
PM_{10}	Particulate matter less than or equal to 10 microns
ppm	Parts per million
ppmv	Parts per million by volume
PSAT	Particulate Matter Source Apportionment Technology
RACT	Reasonably Available Control Technology

RBT	Refinery to Bulk Terminal
RIA	Regulatory Impact Analysis
RICE	Reciprocating Internal Combustion Engine
RWC	Residential Wood Combustion
RPD	Rate-per-vehicle (emission mode used in SMOKE-MOVES)
RPH	Rate-per-hour for hoteling (emission mode used in SMOKE-MOVES)
RPHO	Rate-per-hour for off-network idling (emission mode used in SMOKE-MOVES)
RPP	Rate-per-profile (emission mode used in SMOKE-MOVES)
RPS	Rate-per-start (emission mode used in SMOKE-MOVES)
RPV	Rate-per-vehicle (emission mode used in SMOKE-MOVES)
RVP	Reid Vapor Pressure
SCC	Source Classification Code
SMARTFIRE2	Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOA	Secondary Organic Aerosol
SIP	State Implementation Plan
SPDPRO	Hourly Speed Profiles for weekday versus weekend
S/L/T	state, local, and tribal
TAF	Terminal Area Forecast
TCEQ	Texas Commission on Environmental Quality
TOG	Total Organic Gas
TSD	Technical support document
USDA	United States Department of Agriculture
VIIRS	Visible Infrared Imaging Radiometer Suite
VOC	Volatile organic compounds
VMT	Vehicle miles traveled
VPOP	Vehicle Population
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting Model
2014NEIv2	2014 National Emissions Inventory (NEI), version 2

1 Introduction

The U.S. Environmental Protection Agency (EPA), has created a 2016v3 platform as an update to the 2016v2 emissions modeling platform (EPA, 2021). The 2016v3 platform includes updates in response to comments, some corrections, improved methods, and refinements to some projection factors due to newly released data. The 2016v3 platform is designed to be used studies focused on criteria air pollutants and represents the base year of 2016 and analytic years of 2023 and 2026. The 2016v3 platform primarily draws on data from the 2017 National Emissions Inventory (NEI) (EPA, 2021b), although the emissions were updated to represent the year 2016 through the incorporation of 2016-specific state and local data along with adjustment methods appropriate for each sector. The analytic year inventories were developed starting with the base year 2016 inventory using sector-specific methods as described below. The 2016v3 platform supports applications related to ozone transport and particulate matter.

The full air quality modeling platform consists of all the emissions inventories and ancillary data files used for emissions modeling, as well as the meteorological, initial condition, and boundary condition files needed to run the air quality model. This document focuses on the emissions modeling data and techniques that comprise the emission modeling platform including the emission inventories, the ancillary data files, and the approaches used to transform inventories for use in air quality modeling.

The 2016v3 platform retains some data from the National Inventory Collaborative effort to develop the 2016v1 platform (EPA, 2021c). The National Emissions Inventory Collaborative is a partnership between state emissions inventory staff, multi-jurisdictional organizations (MJOs), federal land managers (FLMs), EPA, and others to develop a North American air pollution emissions modeling platform with a base year of 2016 for use in air quality planning. The Collaborative planned for three versions of the 2016 platform: alpha, beta, and Version 1. The numbering format for the 2016 platforms is different from previous EPA platforms which had the first number based on the version of the NEI, and the second number as a platform iteration for that NEI year (e.g., v7.3 where the 7 represents 2014-2016 NEI-based platforms, and 3 means the third iteration of the platform). Using this older numbering method, the 2016v3 platform is also known as the v7.5 platform.

This emissions modeling platform includes all criteria air pollutants (CAPs) and precursors, and a group of hazardous air pollutants (HAPs). The group of HAPs are those explicitly used by the chemical mechanism in the Community Multiscale Air Quality (CMAQ) model (Appel et al., 2018) for ozone/particulate matter (PM): chlorine (Cl), hydrogen chloride (HCl), benzene, acetaldehyde, formaldehyde, methanol, naphthalene. The modeling domain includes the lower 48 states and parts of Canada and Mexico. The modeling cases for this platform were developed for studies with both the CMAQ model and with the Comprehensive Air Quality Model with Extensions (CAMx). The emissions modeling process used first prepares outputs in the format used by CMAQ, after which those emissions data are converted to the formats needed by CAMx.

The 2016v3 platform consists of cases that represent the years 2016, 2023, and 2026 with the abbreviations **2016gf_16j, 2023gf_16j,** and **2026gf_16j**, respectively. Derivatives of these cases that included source apportionment by state were also developed. This platform accounts for atmospheric chemistry and transport within a state-of-the-art photochemical grid model. In the case abbreviation 2016fh_16j, 2016 is the year represented by the emissions; the “f” represents the base year emissions modeling platform iteration, which here shows that f is the 2016 platform which started with the 2014 NEI; and the “j” stands for the tenth configuration of emissions modeled for that modeling platform.

The gridded meteorological model used to provide input data for the emissions modeling was developed using the Weather Research and Forecasting Model (WRF, https://ral.ucar.edu/solutions/products/weather-research-and-forecasting-model-wrf) version 3.8, Advanced Research WRF core (Skamarock, et al., 2008). The WRF Model is a mesoscale numerical weather prediction system developed for both operational forecasting and atmospheric research applications. The WRF was run for 2016 over a domain covering the continental U.S. at a 12km resolution with 35 vertical layers. The run for this platform included high resolution sea surface temperature data from the Group for High Resolution Sea Surface Temperature (GHRSST) (see https://www.ghrsst.org/) and is given the EPA meteorological case label "16j." The full case abbreviation includes this suffix following the emissions portion of the case name to fully specify the abbreviation of the case as "2016gf_16j."

The emissions modeling platform includes point sources, nonpoint sources, commercial marine vessels (CMV), onroad and nonroad mobile sources, and fires for the U.S., Canada, and Mexico. Some platform categories use more disaggregated data than are made available in the NEI. For example, in the platform, onroad mobile source emissions are represented as hourly emissions by vehicle type, fuel type process and road type while the NEI emissions are aggregated to vehicle type/fuel type totals and annual temporal resolution. A full NEI was not developed for the year 2016 because only point sources above a certain potential to emit must be submitted for years between the full triennial NEI years (e.g., 2014, 2017, 2020). Emissions from Canada and Mexico are used for the modeling platform but are not part of the NEI.

The primary emissions modeling tool used to create the air quality model-ready emissions was the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system (http://www.smoke-model.org/), version 4.9 (SMOKE 4.9). Emissions files were created for a 36-km national grid and for a 12-km national grid, both of which include the contiguous states and parts of Canada and Mexico as shown in Figure 3-1. Emissions at 36-km were only created for the inventory years 2016 and 2023.

This document contains six sections and several appendices. Section 2 describes the 2016 inventories input to SMOKE. Section 3 describes the emissions modeling and the ancillary files used to process the emission inventories into air quality model-ready inputs. Methods to develop analytic year emissions are described in Section 4. Data summaries are provided in Section 5. Section 6 provides references. The Appendices provide additional details about specific technical methods or data.

2 Emissions Inventories and Approaches

This section summarizes the emissions data that make up the 2016v3 platform. This section provides details about the data contained in each of the platform sectors for the base year and the analytic year. The original starting point for the emission inventories was the 2016v2 platform, which was released for comment in September of 2021 and continued to be available for comments during the comment periods following publication of EPA actions in response to state submissions of interstate transport state implementation plans (SIPs) and the comment period for the Good Neighbor Plan for the 2015 Ozone National Ambient Air Quality Standard (NAAQS). To create the 2016v3 platform, the 2016v2 inventories were updated to incorporate additional data from the 2017 NEI, implement corrections for some source categories, and to refine inventory methodologies and data in response to comments. Comments submitted through these processes through July of 2022 were considered. Details of the updates for each sector in the base and analytic years are described in this document.

Data and documentation for the 2017NEI, including a TSD, are available from https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data (EPA, 2021b). In addition to the NEI-based data for the broad categories of point, nonpoint, onroad, nonroad, and events (i.e., fires), emissions from the Canadian and Mexican inventories and several other non-NEI data sources are included in the 2016 platform. The Canadian and Mexican inventories were updated in the 2016v2 platform but were not changed in the 2016v3 platform.

The triennial year NEI data for CAPs are largely compiled from data submitted by state, local and tribal (S/L/T) air agencies. A large proportion of HAP emissions data in the NEI are also from the S/L/T agencies, but, are augmented by the EPA when not available from S/L/Ts. The EPA uses the Emissions Inventory System (EIS) to compile the NEI. The EIS includes hundreds of automated quality assurance checks to help improve data quality, and also supports tracking release point (e.g., stack) coordinates separately from facility coordinates. The EPA collaborates extensively with S/L/T agencies to ensure a high quality of data in the NEI. Because 2016 is not a triennial NEI year, all emissions modeling sectors were modified in some way to represent the year 2016 to the extent possible.

For interim years other than triennial NEI years, point source data are typically pulled forward from the most recent triennial NEI year for the sources that were not reported by S/L/Ts for the interim year. Thus, the 2016 point source emission inventories for the platform include emissions primarily from S/L/T-submitted data. In 2016v3, data that would have been pulled forward from 2014 were instead replaced with data from 2017 NEI, where possible, as the 2017 emissions were more current and closer to the year being modeling. Agricultural and wildland fire emissions represent the year 2016 and are consistent with those in 2016v2. In 2016v3, emissions for nonpoint source sectors started with 2017 NEI emissions and some were adjusted to better represent the year 2016. Fertilizer emissions represent the year 2016. Some spatial reallocation was performed for CMV emissions to refine the assignment of the emissions to state waters, but otherwise the 2016v3 CMV emissions are consistent with 2016v2. 2016v3 used new data provided by California Air Resources Board (CARB) for mobile sources in California. Locomotive emissions in the rail and ptnonipm sectors are consistent with those in 2016v1 and v2, with the exception of California. Nonpoint oil and gas emissions were developed using 2016-specific data for oil and gas wells and their 2016 production levels in conjunction with data developed by the Western Regional Air Partnership (WRAP).

Onroad and nonroad mobile source emissions were developed using the Motor Vehicle Emission Simulator (MOVES). Onroad emissions were developed based on emissions factors output from

MOVES3 for the year 2016, run with inputs derived from the 2017NEI along with activity data (e.g., vehicle miles traveled and vehicle populations) provided by state and local agencies for 2016v1 or otherwise backcast to the year 2016. Updates for 2016v3 include corrected emission factors for combination trucks, corrections to road type distributions in some states, and activity data projections based on the 2022 Annual Energy Outlook (AEO). Nonroad emissions were consistent with those in 2016v2 and were generated using MOVES3, including the spatial allocation factors that were updated for the 2016v1 platform.

For the purposes of preparing the air quality model-ready emissions, emissions from the five NEI data categories are split into finer-grained sectors used for emissions modeling. The significance of an emissions modeling or "platform sector" is that the data are run through the SMOKE programs independently from the other sectors except for the final merge. The final merge program (Mrggrid) combines the sector-specific gridded, speciated, hourly emissions together to create CMAQ-ready emission inputs. For studies that use CAMx, the merged CMAQ-ready emissions inputs are converted into the file formats needed by CAMx. Elevated point sources from those are merged into files containing all sources for a given day and those files are converted into the CAMx point source format.

In addition to the NEI-based sectors, emissions for Canada and Mexico are included. In 2016v3, these emissions are based on updated data that represent the base year of 2016 for Canada from ECCC and for Mexico from SEMARNAT.

Table 2-1 presents an overview the sectors in the emissions modeling platform and how they generally relate to the NEI as their starting point. The platform sector abbreviations are provided in italics. These abbreviations are used in the SMOKE modeling scripts, inventory file names, and throughout the remainder of this document. Additional details on the changes made in the 2016v3 platform for each sector are available in the sector-specific subsections that follow.

Other natural emissions are also merged in with the sectors in Table 2-1: ocean chlorine and sea salt, and new for 2016v3: lightning NOx. The ocean chlorine gas emission estimates are based on the build-up of molecular chlorine (Cl_2) concentrations in oceanic air masses (Bullock and Brehme, 2002). In CMAQ, the species name is "CL2". The sea salt emissions were developed with version 4.1 of the OCEANIC pre-processor that comes with the CAMx model. The preprocessor estimates time/space-varying emissions of aerosol sodium, chloride and sulfate; gas-phase chlorine and bromine associated with sea salt; gaseous halo-methanes; and dimethyl sulfide (DMS). These additional oceanic emissions are incorporated into the final model-ready emissions files for CAMx. For more information on the natural emissions, including the lightning NOx, see Section 2.7.6.

The emission inventories in SMOKE input formats for the platform are available from EPA's Air Emissions Modeling website: https://www.epa.gov/air-emissions-modeling/2016v3-platform , The platform informational text file describes the particular zipped files associated with each platform sector and provides notes about how SMOKE should be run for each sector. A number of reports (i.e., summaries) are available in addition to the data files for the 2016 platform. The types of reports include state summaries of inventory pollutants and model species by modeling platform sector and county annual totals by modeling platform sector.

Table 2-1. Platform sectors for the 2016 emissions modeling case

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
EGU units: ***ptegu***	Point	Point source electric generating units (EGUs) for 2016 from the Emissions Inventory System (EIS), based on 2016v1 with some updates. Includes some adjustments to default stack parameters, additional closures, and a few units that were previously in ptnonipm. The inventory emissions are replaced with hourly 2016 Continuous Emissions Monitoring System (CEMS) values for nitrogen oxides (NO_X) and SO_2 for any units that are matched to the NEI, and other pollutants for matched units are scaled from the 2016 point inventory using CEMS heat input. Emissions for all sources not matched to CEMS data come from the annual inventory. For 2016v3 most 2014-projected emissions were replaced with emissions from the 2017NEI. Annual resolution for sources not matched to CEMS data, hourly for CEMS sources.
Point source oil and gas: ***pt_oilgas***	Point	Point sources for 2016 including S/L/T data for oil and gas production and related processes and updated from 2016v1 with the Western Regional Air Partnership (WRAP) 2014 inventory. Includes sources from facilities with the following NAICS: 2111, 21111, 211111, 211112 (Oil and Gas Extraction); 213111 (Drilling Oil and Gas Wells); 213112 (Support Activities for Oil and Gas Operations); 2212, 22121, 221210 (Natural Gas Distribution); 48611, 486110 (Pipeline Transportation of Crude Oil); 4862, 48621, 486210 (Pipeline Transportation of Natural Gas). Includes offshore oil and gas platforms in the Gulf of Mexico (FIPS=85). For 2016v3 most emissions projected from 2014 were replaced with 2017NEI emissions. Annual resolution.
Aircraft and ground support equipment: ***airports***	Point	Emissions from aircraft up to 3,000 ft elevation and emissions from ground support equipment based on the January 2021 version of 2017 NEI and backcast to 2016. For 2016v3 there were adjustments to Atlanta (ATL) and to a few specific airports in Texas based on comments. Annual resolution.
Remaining non-EGU point: ***ptnonipm***	Point	All 2016 point source inventory records not matched to the ptegu, airports, or pt_oilgas sectors, including updates submitted by state and local agencies including some sources that were not operating in 2016 but did operate in later years. Year 2016 rail yard emissions were developed by the 2016v1 rail workgroup. For 2016v2 NOx control efficiencies were updated where new information was available. A few sources were moved to ptegu in 2016v2 and 2016v3. For 2016v3 most 2014-projected emissions were replaced with emissions from the 2017NEI, facilities found to overlap with the biorefinery inventory were removed along with biofuel facilities that were double counted in 2016v2, emissions were updated for five biofuel facilities, point solvents not in 2016v2 were restored, California rail yard emissions were updated to reflect new data from CARB, and some other minor changes. Annual resolution.
Agricultural fertilizer: ***fertilizer***	Nonpoint	Nonpoint agricultural fertilizer application emissions of ammonia estimated for 2016 using the FEST-C model and captured from a run of CMAQ for 2016. For 2016v3 corrected to use NH3 molecular weight. County and monthly resolution.
Agricultural Livestock: ***livestock***	Nonpoint	Nonpoint agricultural livestock emissions including ammonia and other pollutants (except $PM_{2.5}$) backcast from 2017NEI based on animal population data from the U.S. Department of Agriculture (USDA) National Agriculture Statistics Service Quick Stats, where available. For 2016v3 Maryland and Illinois emissions were corrected. County and annual resolution.

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
Agricultural fires with point resolution: *ptagfire*	Nonpoint	2016 agricultural fire sources based on EPA-developed data with state updates, represented as point source day-specific emissions. They are in the nonpoint NEI data category, but in the platform, they are treated as point sources. For 2016v3 data are unchanged from 2016v2. Mostly at daily resolution with some state-submitted data at monthly resolution.
Area fugitive dust: *afdust*	Nonpoint	PM_{10} and $PM_{2.5}$ fugitive dust sources based on the 2017 NEI nonpoint inventory, including building construction, road construction, agricultural dust, and road dust. Agricultural dust, paved road dust, and unpaved road dust were backcast to 2016 levels. The NEI emissions are reduced during modeling according to a transport fraction (computed for the 2016 platform) and a meteorology-based (precipitation and snow/ice cover) zero-out. Afdust emissions from the portion of Southeast Alaska inside the 36US3 domain are processed in a separate sector called 'afdust_ak'. For 2016v3 data are unchanged from 2016v2. County and annual resolution.
Biogenic: *beis*	Nonpoint	Year 2016, hour-specific, grid cell-specific emissions generated from the BEIS4 model within SMOKE, including emissions in Canada and Mexico using BELD6 land use data. For 2016v3 the versions of BEIS and BELD were updated. Gridded and hourly resolution.
Category 1, 2 CMV: *cmv_c1c2*	Nonpoint	Category 1 and category 2 (C1C2) commercial marine vessel (CMV) emissions sources backcast to 2016 from the 2017NEI using a multiplier of 0.98. Includes C1C2 emissions in U.S. state and Federal waters, and also all non-U.S. C1C2 emissions including those in Canadian waters. For 2016v3, spatial allocation to county boundaries was improved but otherwise emissions were unchanged from 2016v2. Gridded and hourly resolution.
Category 3 CMV: *cmv_c3*	Nonpoint	Category 3 (C3) CMV emissions converted to point sources based on the center of the grid cells. Includes C3 emissions in U.S. state and Federal waters, and also all non-U.S. C3 emissions including those in Canadian waters. Emissions are backcast to 2016 from 2017NEI emissions based on factors derived from U.S. Army Corps of Engineers Entrance and Clearance data and information about the ships entering the ports. For 2016v3, spatial allocation to county boundaries was improved but otherwise emissions were unchanged from 2016v2. Gridded and hourly resolution.
Locomotives : *rail*	Nonpoint	Line haul rail locomotives emissions developed by the 2016v1 rail workgroup based on 2016 activity and emission factors. Includes freight and commuter rail emissions and incorporates state and local feedback. For 2016v3 data are unchanged from 2016v1 and 2016v2. County and annual resolution.
Solvents : *np_solvents*	Nonpoint (some Point)	VOC emissions from solvents for 2016 derived using the VCPy framework (Seltzer et al., 2021) along with some data from 2017 NEI. Includes cleaners, personal care products, adhesives, architectural coatings, and aerosol coatings, industrial coatings, allied paint products, printing inks, dry-cleaning emissions, and agricultural pesticides. For 2016v3 updated methods were used in VCPy. County and annual resolution.
Nonpoint source oil and gas: *np_oilgas*	Nonpoint	2016 nonpoint oil and gas emissions. Based on output from the 2017NEI version of the Oil and Gas tool for the year 2016 along with the 2014 WRAP oil and gas inventory for production-related emissions in those states and Pennsylvania's unconventional well inventory. Exploration-related emissions are based on the 2017NEI version of the Oil and Gas Tool run for 2016. For 2016 updated Colorado, Oklahoma, and Texas emission. County and annual resolution

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
Residential Wood Combustion: ***rwc***	Nonpoint	2017 NEI nonpoint sources from residential wood combustion (RWC) processes backcast to the year 2016. For 2016v3 updated Idaho so use 2017 NEI emissions. County and annual resolution.
Remaining nonpoint: ***nonpt***	Nonpoint	Nonpoint sources not included in other platform sectors. For 2016 updated to used 2017NEI for all sources except biomass combustion and gas stations which are backcast from 2017 to 2016. County and annual resolution.
Nonroad: ***nonroad***	Nonroad	2016 nonroad equipment emissions developed with MOVES3 using the inputs that were updated for 2016v1. MOVES was used for all states except California and Texas, which submitted emissions for 2016v1. For 2016v3 data are unchanged from 2016v2. County and monthly resolution.
Onroad: ***onroad***	Onroad	2016 onroad mobile source gasoline and diesel vehicles from moving and non-moving vehicles that drive on roads, along with vehicle refueling. Includes the following modes: exhaust, extended idle, auxiliary power units, off network idling, starts, evaporative, permeation, refueling, and brake and tire wear. For all states except California, developed using SMOKE-MOVES with emission factor tables produced by MOVES3 coupled with activity data backcast from 2017NEI to year 2016 or provided for 2016v1 by S/L/T agencies. Onroad emissions for Alaska, Hawaii, Puerto Rico and the Virgin Islands were held constant from 2016v1 (based on MOVES2014b) and are part of the onroad_nonconus sector. For 2016v3 included new starts for 20 Georgia counties, road type and hoteling changes in six states, inspection and maintenance updates in North Carolina and Tennessee and corrected emissions factors for combination trucks. County and hourly resolution.
Onroad California: ***onroad_ca_adj***	Onroad	2016 California-provided CAP onroad mobile source gasoline and diesel vehicles based on the EMFAC model, gridded and temporalized using MOVES3 outputs. Volatile organic compound (VOC) HAP emissions derived from California-provided VOC emissions and MOVES-based speciation. For 2016v3 minor updates to the NH3 and refueling emissions that are based on MOVES due to changes in combination truck emission factors. County and hourly resolution.
Point source fires- ***ptfire-rx*** ***ptfire-wild***	Events	Point source day-specific wildfires and prescribed fires for 2016 computed using Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2) and BlueSky Framework (Sullivan, 2008 and Raffuse, 2007) for both flaming and smoldering processes (i.e., SCCs 281XXXX002). Smoldering is forced into layer 1 (by adjusting heat flux). For 2016v3 data are unchanged from 2016v2. Daily resolution.
Non-US. Fires: ***ptfire_othna***	N/A	Point source day-specific wildland fires for 2016 provided by Environment Canada with data for missing months, and for Mexico and Central America, filled in using fires from the Fire Inventory (FINN) from National Center for Atmospheric Research (NCAR) fires (NCAR, 2016 and Wiedinmyer, C., 2011). Includes any prescribed fires although they are not distinguished from wildfires. For 2016v3 data are unchanged from 2016v2. Daily resolution.
Other Area Fugitive dust sources not from the NEI: ***othafdust***	N/A	Fugitive dust sources of particulate matter emissions excluding land tilling from agricultural activities, from Environment and Climate Change Canada (ECCC) 2016 emission inventory updated for 2016v1. A transport fraction adjustment is applied along with a meteorology-based (precipitation and snow/ice cover) zero-out. For 2016v3 data are unchanged from 2016v2. County and annual resolution.

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
Other Point Fugitive dust sources not from the NEI: ***othptdust***	N/A	Fugitive dust sources of particulate matter emissions from land tilling from agricultural activities, ECCC 2016 emission inventory updated for 2016v1, but wind erosion emissions were removed. A transport fraction adjustment is applied along with a meteorology-based (precipitation and snow/ice cover) zero-out. Data were originally provided on a rotated 10-km grid for beta, but were smoothed so as to avoid the artifact of grid lines in the processed emissions. For 2016v3 data are unchanged from 2016v2. Monthly resolution.
Other point sources not from the NEI: ***othpt***	N/A	Point sources from the ECCC 2016 emission inventory updated for 2016v1. Includes Canadian sources other than agricultural ammonia and low-level oil and gas sources, along with emissions from Mexico's 2016 inventory. For 2016v3 data are unchanged from 2016v2. Monthly resolution for Canada airport emissions, annual resolution for the remainder of Canada and all of Mexico.
Canada ag not from the NEI: ***canada_ag***	N/A	Agricultural point sources from the ECCC 2016 emission inventory updated from 2016v1, including agricultural ammonia. Agricultural data were originally provided on a rotated 10-km grid, but were smoothed so as to avoid the artifact of grid lines in the processed emissions. Data were forced into 2D low-level emissions to reduce the size of othpt. For 2016v3 data are unchanged from 2016v2. Monthly resolution.
Canada oil and gas 2D not from the NEI: ***canada_og2D***	N/A	Low-level point oil and gas sources from the ECCC 2016 emission inventory with emissions forced into 2D low-level to reduce the size of the othpt sector. Point oil and gas sources which are subject to plume rise remain in the othpt sector. For 2016v3 data are unchanged from 2016v2. Annual resolution.
Other non-NEI nonpoint and nonroad: ***othar***	N/A	Year 2016 Canada (province or sub-province resolution) emissions from the ECCC inventory updated for 2016v1. Year 2016 Mexico (municipio resolution) emissions from their 2016 inventory. For 2016v3 data are unchanged from 2016v2. Resolution: Canada monthly for nonroad sources; annual for rail and other nonpoint sectors, Mexico: annual nonpoint and nonroad mobile inventories.
Other non-NEI onroad sources: ***onroad_can***	N/A	Year 2016 Canada (province resolution or sub-province resolution, depending on the province) from the ECCC onroad mobile inventory updated for 2016v1. For 2016v3 data are unchanged from 2016v2. Monthly resolution.
Other non-NEI onroad sources: ***onroad_mex***	N/A	Year 2016 Mexico (municipio resolution) onroad mobile inventory based on MOVES-Mexico runs for 2014 and 2018 then interpolated to 2016 (unchanged from 2016v1). For 2016v3 data are unchanged from 2016v2. Monthly resolution.

2.1 2016 point sources (ptegu, pt_oilgas, ptnonipm, airports)

Point sources are sources of emissions for which specific geographic coordinates (e.g., latitude/longitude) are specified, as in the case of an individual facility. A facility may have multiple emission release points that may be characterized as units such as boilers, reactors, spray booths, kilns, etc. A unit may have multiple processes (e.g., a boiler that sometimes burns residual oil and sometimes burns natural gas). This section describes NEI point sources within the contiguous U.S. and the offshore oil platforms which are processed by SMOKE as point source inventories. A full NEI is compiled every three years including 2011, 2014 and 2017. In the intervening years, emissions information about point sources that exceed certain potential to emit threshold as defined in the Air Emissions Reporting Requirements (AERR)[1] are required to be submitted to the EIS that is used to compile the NEI. A comprehensive description of how EGU emissions were characterized and estimated in the NEI is located in Section 3.4 of the 2014 NEI TSD (EPA, 2018). The methods for emissions estimation are similar for the interim year of 2016, but there is no TSD available specific to the 2016 point source NEI. Information on state submissions for point sources through the 2016v1 collaborative process are available in the collaborative specification sheets (http://views.cira.colostate.edu/wiki/wiki/10202).

The point source file used for the modeling platform was exported from EIS into the Flat File 2010 (FF10) format that is compatible with SMOKE (see https://www.cmascenter.org/smoke/documentation/4.9/html/ch06s02s08.html). The export of point source emissions specific to 2016, including stack parameters and locations from EIS, was done on June 12, 2018, and some modifications were made since that time. For 2016v3, most sources with data not specific to the year 2016 were replaced with data from the 2017 NEI that was exported on June 18, 2020. The flat file was modified to remove sources without specific locations (i.e., their FIPS code ends in 777). Then the point source FF10 was divided into point source sectors used in the platform: the EGU sector (ptegu), point source oil and gas extraction-related emissions (pt_oilgas), airport emissions were put into the airports sector, and the remaining non-EGU sources into the non-IPM (ptnonipm) sector. The split was done at the unit level for ptegu and facility level for pt_oilgas such that a facility may have units and processes in both ptnonipm and ptegu, but units cannot be in both pt_oilgas and any other point sector.

The EGU emissions are split out from the other sources to facilitate the use of distinct SMOKE temporal processing and analytic-year projection techniques where the Integrated Planning Model (IPM) is used to project EGU emissions and other techniques are used to project non-EGU emissions. The oil and gas sector emissions (pt_oilgas) were processed separately for summary tracking purposes and distinct analytic-year projection techniques from the remaining non-EGU emissions (ptnonipm).

The inventory pollutants processed through SMOKE for all point source sectors were carbon monoxide (CO), NO_X, VOC, SO_2, ammonia (NH_3), particles less than 10 microns in diameter (PM_{10}), and particles less than 2.5 microns in diameter ($PM_{2.5}$), and all of the air toxics listed in Table 3-3. The pollutants naphthalene, benzene, acetaldehyde, formaldehyde, and methanol (NBAFM) species are based on speciation of VOCs. The resulting VOC in the modeling system may be higher or lower than the VOC emissions in the NEI; they would only be the same if the HAP inventory and speciation profiles were exactly consistent. For HAPs other than those in NBAFM, there is no concern for double-counting since CMAQ handles these outside the CB6 mechanism.

The ptnonipm and pt_oilgas sector emissions were provided to SMOKE as annual emissions. For those ptegu sources with CEMS data that could be matched to the point inventory from EIS, hourly CEMS NO_X and SO_2 emissions were used rather than the annual total NEI emissions. For all other pollutants at matched units, the annual emissions were used as-is from the NEI, but were allocated to hourly values using heat input from the CEMS data. For the sources in the ptegu sector not matched to CEMS data, daily emissions were created using an approach described in Section 2.1.1. For non-CEMS units other than municipal waste combustors and cogeneration units, region- and pollutant-specific diurnal profiles were applied to create hourly emissions.

[1] 80 FR 8787 pubished 2/19/2015. See: https://www.federalregister.gov/documents/2015/02/19/2015-03470/revisions-to-the-air-emissions-reporting-requirements-revisions-to-lead-pb-reporting-threshold-and

While reviewing recent point source inventories it was determined that data submitted by some agencies used specific default values for certain stack parameters that are not necessarily appropriate to use for those sources. This can impact modeling results, especially in fine scale modeling. When the stack parameters were substantially different from average values for that source type, the defaulted stack parameters were replaced with the value from the SMOKE PSTK file for that SCC. The agencies and default values that were replaced are shown in Table 2-2. Comments for any impacted inventory records were appended in the FF10 inventory files with comments of the form "stktemp replaced with ptsk default" so the updated records could be identified.

Table 2-2. Default stack parameter replacements

Agency abbreviation	Stkdiam	Stkhgt	Stktemp	Stkvel
CODPHE	0.1 ft	1 ft	70 degF or 72 degF	
PADEP	0.1 ft	1 ft	70 degF	0.1 ft/s or 1000 ft/s
LADEQ	0.3 ft		70 degF or 77 degF	0.1 ft/s
ILEPA	0.33 ft	33 ft or 35 ft	70 degF	
TXCEQ	1 ft or 3 ft	40 ft	72 degF	0.1 ft/s
NVBAQ		32.8 ft	72 degF	
WIDNR		20 ft		3.281 ft/s
MIDEQ			70 degF or 72 degF	
MNPCA			70 degF	
IADNR			68 degF or 70 degF	
ORDEQ			72 degF	
MSDEQ			72 degF	
SCDEQ			72 degF	1 ft/s
NCDAQ			72 degF	0.2 ft/s
INDEM			0 degF	0 ft/s
NEDEQ			350 degF	1.6666 ft/s
KYDAQ				0 ft/s
WYDEQ				11.46 ft/s

2.1.1 EGU sector (ptegu)

The ptegu sector contains emissions from EGUs in the 2016 NEI point inventory that could be matched to units found in the National Electric Energy Data System (NEEDS) v6.20 database (https://www.epa.gov/airmarkets/national-electric-energy-data-system-needs-v6 dated 8/3/2022). The matching was prioritized according to the amount of the emissions produced by the source. In the SMOKE point flat file, emission records for sources that have been matched to the NEEDS database have a value filled into the IPM_YN column based on the matches stored within EIS. The 2016 NEI point inventory consists of data submitted by S/L/T agencies and EPA to the EIS for Type A (i.e., large) point sources. Those EGU sources in the 2014 NEIv2 inventory that were not submitted or updated for 2016 and not identified as retired were retained in 2016, but for 2016v3 the emissions values were pulled from the 2017 NEI where possible. For any 2014 EGU emissions that remain in the 2016v3 inventory, those from the states CT, DE, DC, ME, MD, MA, NH, NJ, NY, NC, PA, RI, VT, VA, and WV were projected from 2014 to 2016 values using factors provided by the Mid-Atlantic Regional Air Management Association (MARAMA).

When possible, units in the ptegu sector are matched to 2016 CEMS data from EPA's Clean Air Markets Division (CAMD) via ORIS facility codes and boiler ID (see https://campd.epa.gov/). For the matched units, SMOKE replaces the 2016 emissions of NO_X and SO_2 with the CEMS emissions, thereby ignoring the annual values specified in the NEI annual FF10 flat file. For other pollutants at matched units, the hourly CEMS heat input data are used to allocate the NEI annual emissions to hourly values. All stack parameters, stack locations, and Source Classification Codes (SCC) for these sources come from the NEI or updates provided by data submitters outside of EIS. Because these attributes are obtained from the NEI, the chemical speciation of VOC and $PM_{2.5}$ for the sources is selected based on the SCC or in some cases, based on unit-specific data. If CEMS data exists for a unit, but the unit is not matched to the NEI, the CEMS data for that unit are not used in the modeling platform. However, if the source exists in the NEI and is not matched to a CEMS unit, the emissions from that source are still modeled using the annual emission value in the NEI temporally allocated to hourly values. The EGU flat file inventory is split into a flat file with CEMS matches and a flat file without CEMS matches to support analysis and temporal allocation to hourly values.

In the SMOKE point FF10 file, emission records for point sources matched to CEMS data have values filled into the ORIS_FACILITY_CODE and ORIS_BOILER_ID columns. The CEMS data in SMOKE-ready format is available at https://gaftp.epa.gov/DMDnLoad/emissions/smoke/. Many smaller emitters in the CEMS program are not identified with ORIS facility or boiler IDs that can be matched to the NEI due to inconsistencies in the way a unit is defined between the NEI and CEMS datasets, or due to uncertainties in source identification such as inconsistent plant names in the two data systems. Also, the NEEDS database of units modeled by IPM includes many smaller emitting EGUs that do not have CEMS. Therefore, there will be more units in the NEEDS database than have CEMS data. The temporal allocation of EGU units matched to CEMS is based on the CEMS data, whereas regional profiles are used for most of the remaining units. More details can be found in Section 3.3.2.

Some EIS units match to multiple CAMD units based on cross-reference information in the EIS alternate identifier table. The multiple matches are used to take advantage of hourly CEMS data when a CAMD unit specific entry is not available in the inventory. Where a multiple match is made, the EIS unit is split and the ORIS facility and boiler IDs are replaced with the individual CAMD unit IDs. The split EIS unit NOX and SO2 emissions annual emissions are replaced with the sum of CEMS values for that respective unit. All other pollutants are scaled from the EIS unit into the split CAMD unit using the fraction of annual heat input from the CAMD unit as part of the entire EIS unit. The NEEDS ID in the "ipm_yn" column of the flat file is updated with a "_M_" between the facility and boiler identifiers to signify that the EIS unit had multiple CEMS matches. The inventory records with multiple matches had the EIS unit identifiers appended with the ORIS boiler identifier to distinguish each CEMS record in SMOKE.

For sources not matched to CEMS data, except for municipal waste combustors (MWCs) waste-to-energy and cogeneration units, daily emissions were computed from the NEI annual emissions using average CEMS data profiles specific to fuel type, pollutant,[2] and IPM region. To allocate emissions to each hour of the day, diurnal profiles were created using average CEMS data for heat input specific to fuel type and IPM region. See Section 3.3.2 for more details on the temporal allocation approach for ptegu sources.

[2] The year to day profiles use NOx and SO_2 CEMS for NOx and SO_2, respectively. For all other pollutants, they use heat input CEMS data.

MWC and cogeneration units without CEMS data available were specified to use uniform temporal allocation such that the emissions are allocated to constant levels for every hour of the year. These sources do not use hourly CEMs, and instead use a PTDAY file with the same emissions for each day, combined with a uniform hourly temporal profile applied by SMOKE.

After the completion of 2016v1, it was determined that SMOKE was having an issue properly processing CEMS emissions when there are multiple CEMS units mapped to the same NEI unit. This caused NOx and SO2 emissions in 2016v1 to be higher than they should have been at some units. This issue was corrected in 2016v2 and 2016v3.

2.1.2 Point source oil and gas sector (pt_oilgas)

The pt_oilgas sector consists of point source oil and gas emissions in United States, primarily pipeline-transportation and some upstream exploration and production. Sources in the pt_oilgas sector consist of sources which are not electricity generating units (EGUs) and which have a North American Industry Classification System (NAICS) code corresponding to oil and gas exploration, production, pipeline-transportation or distribution. The pt_oilgas sector was separated from the ptnonipm sector by selecting sources with specific NAICS codes shown in Table 2-3. The use of NAICS to separate out the point oil and gas emissions forces all sources within a facility to be in this sector, as opposed to ptegu where sources within a facility can be split between ptnonipm and ptegu sectors. A major update in 2016v2 was the incorporation of the WRAP oil and gas inventory for the states of Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, and Wyoming. This inventory is described in more detail below and in the WRAP Final report located here:
http://www.wrapair2.org/pdf/WRAP_OGWG_Report_Baseline_17Sep2019.pdf (WRAP / Ramboll, 2019).

The 2016v3 pt_oilgas inventory includes 2017NEI emissions for many states, while others remain the same as 2016v2. Additionally, Colorado emissions were retained from 2016v1 and some New Mexico sources' emissions were replaced with 2020NEI-based emissions backcast to 2016 in response to comments. These changes are in addition those made in 2016v2, where several New Mexico sources were removed from the ptnonipm sector because it was determined they duplicated sources in the WRAP oil and gas inventory. The duplicate sources are listed in Table 2-4. Finally, following a review of the incidence of default stack parameters in recent inventories, stack parameters in the states of Louisiana, Illinois, Nebraska, Texas, Wisconsin, and Wyoming were updated in 2016v2 for sources with values found to be defaults.

Table 2-3. Point source oil and gas sector NAICS Codes

NAICS	NAICS description
2111	Oil and Gas Extraction
211111	Crude Petroleum and Natural Gas Extraction
211112	Natural Gas Liquid Extraction
21112	Crude Petroleum Extraction
211120	Crude Petroleum Extraction
21113	Natural Gas Extraction
211130	Natural Gas Extraction
213111	Drilling Oil and Gas Wells
213112	Support Activities for Oil and Gas Operations

NAICS	NAICS description
2212	Natural Gas Distribution
22121	Natural Gas Distribution
221210	Natural Gas Distribution
237120	Oil and Gas Pipeline and Related Structures Construction
4861	Pipeline Transportation of Crude Oil
48611	Pipeline Transportation of Crude Oil
486110	Pipeline Transportation of Crude Oil
4862	Pipeline Transportation of Natural Gas
48621	Pipeline Transportation of Natural Gas
486210	Pipeline Transportation of Natural Gas

Table 2-4. Sources removed from pt_oilgas due to Overlap with WRAP Oil and Gas Inventory

State+county FIPS	Facility ID	Facility Name
35015	7411811	Artesia Gas Plant
35015	17128911	Chaparral Gas Plant
35015	7761811	DCP Midstream – Peco
35015	7584511	Empire Abo Gas Plant
35015	7905211	Oxy - Indian Basin G
35025	5228911	DCP Midstream – Euni
35025	8091311	Denton Gas Plant
35025	8092311	Eunice Gas Processing Plant
35025	5226911	Jal No3 Gas Plant
35025	8241211	Linam Ranch Gas Plant
35025	5226611	Maljamar Gas Plant
35025	8241411	Saunders Gas Plant
35025	8241311	Targa - Monument Gas Plant
35045	7230311	Kutz Canyon Processing Plant
35045	8091911	San Juan River Gas Plant
35045	7992811	Val Verde Treatment Plant

The starting point for most states in the 2016v3 emissions platform pt_oilgas inventory was the 2016 point source NEI. The 2016 inventory includes data submitted by S/L/T agencies and EPA to the EIS for Type A (i.e., large) point sources. For the federally-owned offshore point inventory of oil and gas platforms, a 2017 inventory was developed by the U.S. Department of the Interior, Bureau of Ocean and Energy Management, Regulation, and Enforcement (BOEM) and this was used in 2016v3, along with any tribal submissions in the pt_oilgas sector. Other states that used 2017NEI emissions for the pt_oilgas sector include Arkansas, California, Delaware, Georgia, Idaho, Indiana, Kentucky, Massachusetts, Mississippi, Nevada, Oklahoma[3], Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee and West Virginia. Although North Dakota provided some stack parameter updates for some pt_oilgas sources, they could not be matched to the WRAP oil and gas inventory used for North Dakota, so these updates could not be implemented.

The year 2016 pt_oilgas inventory in 2016v3 includes a limited number of sources with data carried forward from the 2014NEIv2 point inventory and projected to 2016. The NEI year that the data was submitted for is indicated by the calc_year field in the FF10 inventory files. The pt_oilgas inventory was split into two components: one for 2016 sources, and one for 2014 sources. The sources with calc_year equal to 2016 were used in the platform without further modification.

For pt_oilgas emissions that were carried forward from the 2014NEIv2, those emissions were projected to represent the year 2016. Each state/SCC/NAICS combination in the inventory was classified as either an oil source, a natural gas source, a combination of oil and gas, or designated as a "no growth" source. Growth factors were based on historical state production data from the Energy Information Administration (EIA) and are listed in Table 2-5. National 2016 pt_oilgas emissions before and after application of 2014-to-2016 projections are shown in Table 2-6. The historical production data for years 2014 and 2016 for oil and natural gas were taken from the following websites:

• https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm (Crude production)
• http://www.eia.gov/dnav/ng/ng_sum_lsum_a_epg0_fgw_mmcf_a.htm (Natural gas production)

The "no growth" sources include all offshore and tribal land emissions, and all emissions with a NAICS code associated with distribution, transportation, or support activities. As there were no 2015 production data in the EIA for Idaho, no growth was assumed for this state; the only pt_oilgas sources in Idaho were pipeline transportation related. Maryland and Oregon had no oil production data on the EIA website. The factors in Table 2-5 were applied to sources with NAICS = 2111, 21111, 211111, 211112, and 213111 and with production-related SCC processes. Table 2-5 provides a national summary of emissions before and after this two-year projection for these sources in the pt_oilgas sector. States listed with N/A as values do not have oil and gas activity data from which projection factors could be developed and therefore were held flat with no change from 2014 to 2016. Table 2-6 shows the national emissions for pt_oilgas following the projection to 2016. These numbers are smaller than in 2016v2 because more 2017 data were used in 2016v3 and the numbers only reflect the portion of the inventory projected from 2014 to 2016.

Table 2-5. 2014NEIv2-to-2016 projection factors for pt_oilgas sector for 2016v1 inventory

State	Natural Gas growth	Oil growth	Combination gas/oil growth
Alabama	-9.0%	-17.5%	-13.2%
Alaska	1.9%	-1.1%	0.4%
Arizona	-55.7%	-85.7%	-70.7%
Kansas	-15.0%	-23.4%	-19.2%
Louisiana	-11.0%	-17.4%	-14.2%
Maryland	70.0%	N/A	N/A
Michigan	-12.6%	-23.4%	-18.0%

[3] In Oklahoma, some facilities had significant differences between the 2016 and 2017 emissions. For those facilities, year 2016 data were used where emissions were submitted specifically for the year 2016.

State	Natural Gas growth	Oil growth	Combination gas/oil growth
Minnesota	N/A	N/A	N/A
North Carolina	N/A	N/A	N/A
Ohio	181.0%	44.4%	112.7%
Texas	-6.1%	1.0%	-2.6%
Virginia	-10.0%	-50.0%	-30.0%
Wisconsin	N/A	N/A	N/A

Table 2-6. 2014NEI-based sources in 2016gf pt_oilgas (excluding offshore) before and after the 2014-to-2016 projections for (tons/year)

Pollutant	Before projections	After projections	% change 2014 to 2016
CO	7,846	7,662	-2.3%
NH3	0.0525	0.0527	0.4%
NOX	12,927	12,719	-1.6%
PM10-PRI	529	528	-0.1%
PM25-PRI	498	497	-0.4%
SO2	1,977	1,911	-3.3%
VOC	4,857	4,813	-0.9%

2.1.3 Non-IPM sector (ptnonipm)

With minor exceptions, the ptnonipm sector contains point sources that are not in the airport, ptegu or pt_oilgas sectors. For the most part, the ptnonipm sector reflects the non-EGU sources of the NEI point inventory; however, it is likely that some small low-emitting EGUs not matched to the NEEDS database or to CEMS data are present in the ptnonipm sector. The ptnonipm emissions in the 2016v3 platform have been updated from the 2016 NEI point inventory and 2016v2 with the following changes.

Updates in 2016v3 platform as compared to 2016v2

- The point solvent emissions that had been removed in 2016v2 were added back (point source solvents have been subtracted out of VCPy / nonpoint solvents.
- Three Iowa biofuel facilities that had been supplemented with EPA data that were double counted with state-submitted data in the NEI were removed from the inventory (Facility IDs: OTAQ70212, and two with the ID OTAQ70214).
- Biorefinery emissions for five Iowa biofuel facilities were adjusted based on state-submitted emissions.
- Added three facilities in Kansas that were previously missing.
- Replaced emissions for all source-pollutants projected from 2014 to 2017 where a match could be made to 2017.
- Some facilities moved from ptnonipm to pt_oilgas due to NAICS changes between the platforms.
- Replaced release point IDs and stack parameters with 2019 release point IDs and stack parameters for those North Dakota release points that were identified by ND.

- Removed 17 biorefinery facilities that were found to overlap with the biorefinery inventory.
- Closed refineries that were not operating in 2016.

For 2016v2, A review of stack parameters (i.e., height, diameter, velocity, temperature) was performed to look for default values submitted for many stacks for the same type of source in the inventory. When these parameters were substantially different from average values for that source type, the defaulted stack parameters were replaced with the value from the SMOKE PSTK file for that SCC as shown in Table 2-2. These stack parameter changes were retained in 2016v3.

Changes that were made in the 2016v2 ptnonipm inventory and were retained in 2016v3 are:

- Select municipal waste combustion (MWC) sources were moved from ptnonipm to ptegu as a result of better matching with NEEDS. These include EIS unit identifiers 85563113, 87378913, 119255113, 112010313.
- Sources that were identified to overlap with the WRAP oil and gas inventory including a number of gas plants were removed from ptnonipm.
- Sources that were identified as not operating in 2016 but operating in other recent years were added. These names (and EIS Facility IDs) of these sources were: COLOWYO COAL CO - COLOWYO & COLLOM MINES (1839411), Northshore Mining Co - Silver Bay (6319411), US Steel Corp – Keetac (13598411), United Taconite LLC - Fairlane Plant (6239611), MISSISSIPPI SILICON LLC (17942211), TRIDENT (7766011), and WISCONSIN RAPIDS WWTF (17658711).
- Year 2018 emissions were used for facilities 7766011, 17942211, and 1839411 because the 2018 inventory included CO and NOx, while year 2017 values were used for the others. Although two of these sources were later found to have already been in the ptnonipm inventory but with lower emissions, resulting in a double count in 2016 only.
- The Guardian Corp facility (#2989611) was removed because it closed in 2015.
- Emissions for specific rail yards in Georgia were updated at the request of the state. The specific rail yards updated were: Austell, North Doraville, Krannert, Inman, Industry, Howells, and Tilford.
- NOx control efficiencies were added to ptnonipm sources after a review of permitted limits was conducted, but this does not impact base year emissions.

2.1.4 Aircraft and ground support equipment (airports)

The airport sector contains emissions of all pollutants from aircraft, categorized by their itinerant class (i.e., commercial, air taxi, military, or general), as well as emissions from ground support equipment. The starting point for the 2016v2 and 2016v3 platform year 2016 airport inventories is the airport emissions from the January 2021 version of the 2017 NEI. The SCCs included in the airport sector are shown in Table 2-7.

Table 2-7. 2016v2 platform SCCs for the airports sector

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2265008005	Mobile Sources	Off-highway Vehicle Gasoline, 4-stroke	Airport Ground Support Equipment	Airport Ground Support Equipment
2267008005	Mobile Sources	LPG	Airport Ground Support Equipment	Airport Ground Support Equipment
2268008005	Mobile Sources	compressed natural gas (CNG)	Airport Ground Support Equipment	Airport Ground Support Equipment
2270008005	Mobile Sources	Off-highway Vehicle Diesel	Airport Ground Support Equipment	Airport Ground Support Equipment
2275001000	Mobile Sources	Aircraft	Military Aircraft	Total
2275020000	Mobile Sources	Aircraft	Commercial Aircraft	Total: All Types
2275050011	Mobile Sources	Aircraft	General Aviation	Piston
2275050012	Mobile Sources	Aircraft	General Aviation	Turbine
2275060011	Mobile Sources	Aircraft	Air Taxi	Piston
2275060012	Mobile Sources	Aircraft	Air Taxi	Turbine
2275070000	Mobile Sources	Aircraft	Aircraft Auxiliary Power Units	Total
40600307	Chemical Evaporation	Transportation and Marketing of Petroleum Products	Gasoline Retail Operations – Stage I	Underground Tank Breathing and Emptying
20200102	Internal Combustion Engines	Industrial	Distillate Oil (Diesel)	Reciprocating

The 2016v1 airport emissions inventory was created from the 2017 NEI airport emissions that were estimated using the Federal Aviation Administration's (FAA's) Aviation Environmental Design Tool (AEDT). Additional information about the 2017NEI airport inventory and the AEDT can be found in the 2017 National Emissions Inventory Technical Support Document (EPA, 2021c). The 2017 NEI emissions were adjusted from 2017 to represent year 2016 emissions using FAA data. Adjustment factors were created using airport-specific numbers, where available, or the state default by itinerant class (commercial, air taxi, and general) where there were not airport-specific values in the FAA data. Emissions growth for facilities was capped at 500% and the state default growth was capped at 200%. Military state default values were kept flat to reflect uncertainly in the data regarding these sources.

After the release of the April 2020 version of the 2017 NEI, an error in the computation of the NEI airport emissions was identified and it was determined that they were overestimated. The error impacted commercial aircraft emissions. The airport emissions in 2016v2 were recomputed based on corrected 2017 NEI emissions that were incorporated into the January 2021 release of 2017 NEI.

For the 2016v3 airport inventory, updates were made to Hartsfield Jackson airport (ATL) to remove minor double counting and to specific airports in Texas based on comments received from the Georgia Department of Environmental Protection and the Texas Commissions on Environmental Quality (TCEQ). Some airport runways cross the grid cell boundaries of the 12 km modeling domain. To provide more realistic spatial apportionment for large airports emissions were allocated by area to the intersection of the 12 km grid cells and the corresponding runway polygons.

2.2 2016 Nonpoint sources (afdust, fertilizer, livestock, np_oilgas, np_solvents, rwc, nonpt)

This section describes the *stationary* nonpoint sources in the NEI nonpoint data category. Locomotives, C1 and C2 CMV, and C3 CMV are included in the NEI nonpoint data category, but are mobile sources that are described in Section 2.4.

Nonpoint tribal emissions submitted to the NEI are dropped during spatial processing with SMOKE due to the configuration of the spatial surrogates. Part of the reason for this is to prevent possible double-counting with county-level emissions and also because spatial surrogates for tribal data are not currently available. These omissions are not expected to have an impact on the results of the air quality modeling at the 12-km resolution used for this platform.

The following subsections describe how the sources in the NEI nonpoint inventory were separated into modeling platform sectors, along with any data that were updated replaced with non-NEI data.

2.2.1 Area fugitive dust (afdust)

The area-source fugitive dust (afdust) sector contains PM_{10} and $PM_{2.5}$ emission estimates for nonpoint SCCs identified by EPA as dust sources. Categories included in the afdust sector are paved roads, unpaved roads and airstrips, construction (residential, industrial, road and total), agriculture production, and mining and quarrying. It does not include fugitive dust from grain elevators, coal handling at coal mines, or vehicular traffic on paved or unpaved roads at industrial facilities because these are treated as point sources so they are properly located. Table 2-8 is a listing of the Source Classification Codes (SCCs) in the afdust sector. For 2016v3 no changes were made from the year 2016 afdust inventory in 2016v2.

Table 2-8. Afdust sector SCCs

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2275085000	Mobile Sources	Aircraft	Unpaved Airstrips	Total
2294000000	Mobile Sources	Paved Roads	All Paved Roads	Total: Fugitives
2294000002	Mobile Sources	Paved Roads	All Paved Roads	Total: Sanding/Salting - Fugitives
2296000000	Mobile Sources	Unpaved Roads	All Unpaved Roads	Total: Fugitives
2311000000	Industrial Processes	Construction: SIC 15 – 17	All Processes	Total
2311010000	Industrial Processes	Construction: SIC 15 – 17	Residential	Total
2311010070	Industrial Processes	Construction: SIC 15 – 17	Residential	Vehicle Traffic
2311020000	Industrial Processes	Construction: SIC 15 – 17	Industrial/Commercial/ Institutional	Total

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2311030000	Industrial Processes	Construction: SIC 15 – 17	Road Construction	Total
2325000000	Industrial Processes	Mining and Quarrying: SIC 14	All Processes	Total
2325060000	Industrial Processes	Mining and Quarrying: SIC 10	Lead Ore Mining and Milling	Total
2801000000	Miscellaneous Area Sources	Ag. Production – Crops	Agriculture – Crops	Total
2801000003	Miscellaneous Area Sources	Ag. Production – Crops	Agriculture – Crops	Tilling
2801000005	Miscellaneous Area Sources	Ag. Production – Crops	Agriculture – Crops	Harvesting
2801000007	Miscellaneous Area Sources	Ag. Production – Crops	Agriculture – Crops	Loading
2801000008	Miscellaneous Area Sources	Ag. Production – Crops	Agriculture - Crops	Transport
2805001000	Miscellaneous Area Sources	Ag. Production – Livestock	Beef cattle - finishing operations on feedlots (drylots)	Dust Kicked-up by Hooves (use 28-05-020, -001, -002, or -003 for Waste
2805001100	Miscellaneous Area Sources	Ag. Production – Livestock	Beef cattle - finishing operations on feedlots (drylots)	Confinement
2805001200	Miscellaneous Area Sources	Agriculture Production – Livestock	Beef cattle - finishing operations on feedlots (drylots)	Manure handling and storage
2805001300	Miscellaneous Area Sources	Agriculture Production – Livestock	Beef cattle - finishing operations on feedlots (drylots)	Land application of manure
2805002000	Miscellaneous Area Sources	Ag. Production – Livestock	Beef cattle production composite	Not Elsewhere Classified
2805003100	Miscellaneous Area Sources	Ag. Production – Livestock	Beef cattle - finishing operations on pasture/range	Confinement
2805007100	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - layers with dry manure management systems	Confinement
2805007300	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - layers with dry manure management systems	Land application of manure
2805008100	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - layers with wet manure management systems	Confinement
2805008200	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - layers with wet manure management systems	Manure handling and storage
2805008300	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - layers with wet manure management systems	Land application of manure
2805009100	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production – broilers	Confinement
2805009200	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - broilers	Manure handling and storage
2805009300	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - broilers	Land application of manure
2805010100	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - turkeys	Confinement
2805010200	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - turkeys	Manure handling and storage
2805010300	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - turkeys	Land application of manure

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805018000	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle composite	Not Elsewhere Classified
2805019100	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - flush dairy	Confinement
2805019200	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - flush dairy	Manure handling and storage
2805019300	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - flush dairy	Land application of manure
2805020002	Miscellaneous Area Sources	Ag. Production – Livestock	Cattle and Calves Waste Emissions	Beef Cows
2805021100	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - scrape dairy	Confinement
2805021200	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - scrape dairy	Manure handling and storage
2805021300	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - scrape dairy	Land application of manure
2805022100	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - deep pit dairy	Confinement
2805022200	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - deep pit dairy	Manure handling and storage
2805022300	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - deep pit dairy	Land application of manure
2805023100	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - drylot/pasture dairy	Confinement
2805023200	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - drylot/pasture dairy	Manure handling and storage
2805023300	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle - drylot/pasture dairy	Land application of manure
2805025000	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production composite	Not Elsewhere Classified (see also 28-05-039, -047, -053)
2805030000	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry Waste Emissions	Not Elsewhere Classified (see also 28-05-007, -008, -009)
2805030007	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry Waste Emissions	Ducks
2805030008	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry Waste Emissions	Geese
2805035000	Miscellaneous Area Sources	Ag. Production – Livestock	Horses and Ponies Waste Emissions	Not Elsewhere Classified
2805039100	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - operations with lagoons (unspecified animal age)	Confinement
2805039200	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - operations with lagoons (unspecified animal age)	Manure handling and storage
2805039300	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - operations with lagoons (unspecified animal age)	Land application of manure
2805040000	Miscellaneous Area Sources	Ag. Production – Livestock	Sheep and Lambs Waste Emissions	Total
2805045000	Miscellaneous Area Sources	Ag. Production – Livestock	Goats Waste Emissions	Not Elsewhere Classified

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805047100	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - deep-pit house operations (unspecified animal age)	Confinement
2805047300	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - deep-pit house operations (unspecified animal age)	Land application of manure
2805053100	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - outdoor operations (unspecified animal age)	Confinement

The starting point for the afdust emissions in 2016v3 is the 2017 NEI. The methodologies to estimate emissions for each SCC in the preceding table are described in the 2017 NEI Technical Support Document (EPA, 2021d). The 2017 afdust emissions were adjusted to better represent 2016 as described below.

For paved roads (SCC 2294000000) in non-MARAMA states, the 2017 NEI paved road emissions in afdust were projected to year 2016 based on differences in county total vehicle miles traveled (VMT) between 2017 and 2016:

*2016 afdust paved roads = 2017 afdust paved roads * (2016 county total VMT) / (2017 county total VMT)*

The development of the 2016 VMT is described in the onroad section. VMT data were updated for the 2016v3 to refine the road type distributions in the states of FL, IL, MN, MO, SC, and WV based on data available from the 2020 NEI process. This was done because the 2016v2 and earlier road type distributions had unrealistic spatial distributions of restricted roads. SCCs related to livestock production were backcast using the same factors as were used for the livestock sector. All emissions other than those for paved roads and livestock production are held constant with 2017 levels, including those from unpaved roads.

<u>Area Fugitive Dust Transport Fraction</u>

The afdust sector is separated from other nonpoint sectors to allow for the application of a "transport fraction," and meteorological/precipitation reductions. These adjustments are applied using a script that applies land use-based gridded transport fractions based on landscape roughness, followed by another script that zeroes out emissions for days on which at least 0.01 inches of precipitation occurs or there is snow cover on the ground. The land use data used to reduce the NEI emissions determines the amount of emissions that are subject to transport. This methodology is discussed in Pouliot, et al., 2010, and in "Fugitive Dust Modeling for the 2008 Emissions Modeling Platform" (Adelman, 2012). Both the transport fraction and meteorological adjustments are based on the gridded resolution of the platform (i.e., 12km grid cells); therefore, different emissions will result if the process were applied to different grid resolutions. A limitation of the transport fraction approach is the lack of monthly variability that would be expected with seasonal changes in vegetative cover. While wind speed and direction are not accounted for in the emissions processing, the hourly variability due to soil moisture, snow cover and precipitation is accounted for in the subsequent meteorological adjustment.

For the data compiled into the 2017 NEI, meteorological adjustments are applied to paved and unpaved road SCCs but not transport adjustments. The meteorological adjustments that were applied (to paved and unpaved road SCCs) in the 2017 NEI were backed out so that the entire sector could be processed consistently in SMOKE and the same grid-specific transport fractions and meteorological adjustments could be applied sector-wide. Thus, the FF10 that is run through SMOKE consists of 100% unadjusted emissions, and after SMOKE all afdust sources have both transport and meteorological adjustments applied. The total impacts of the transport fraction and meteorological adjustments for 2016v2 an 2016v3 are shown in Table 2-9. Note that while totals from AK, HI, PR, and VI are included at the bottom of the table, they are from non-continental U.S. (non-CONUS) modeling domains and are held constant from 2016v1.

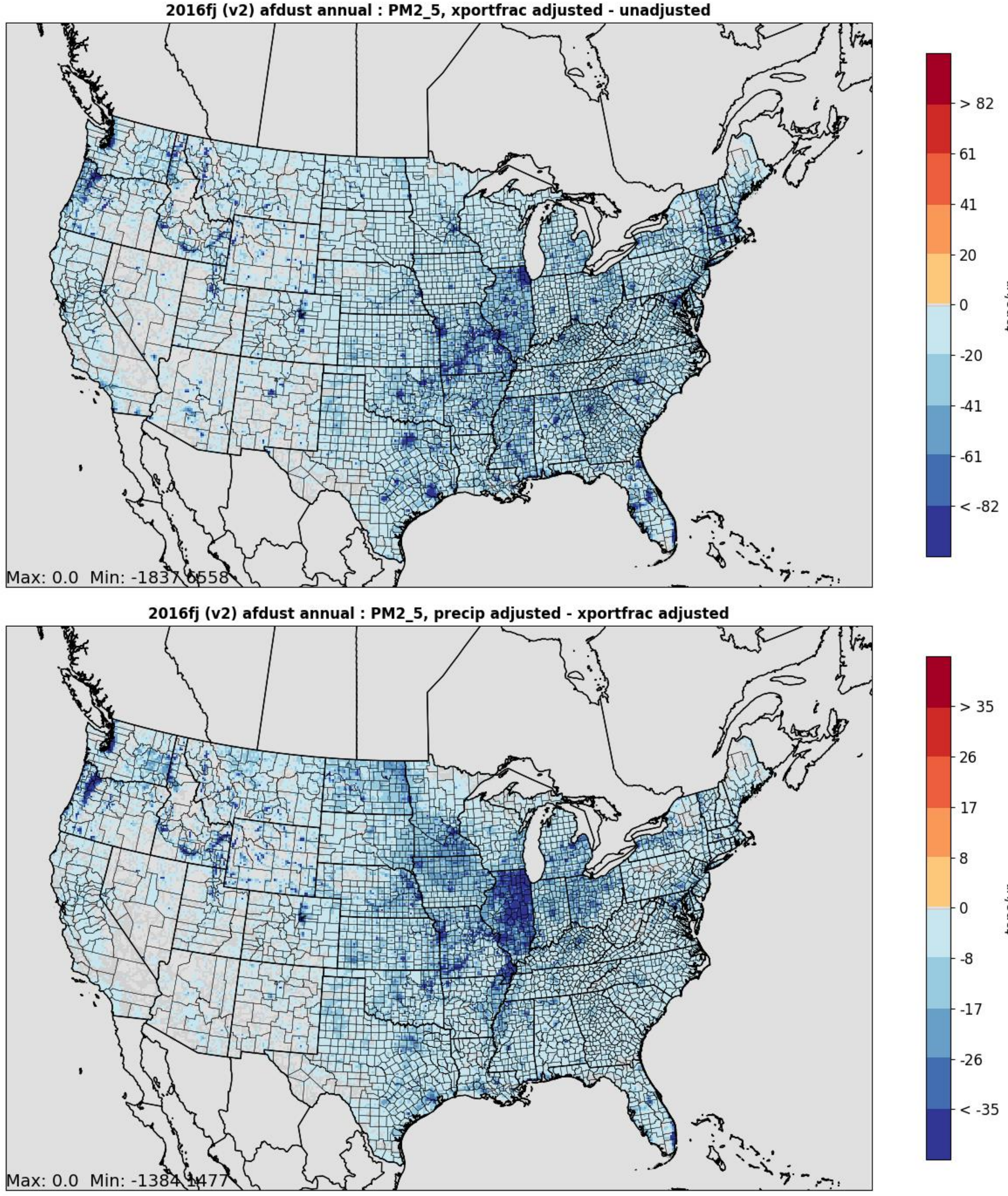
Table 2-9. Total impact of fugitive dust adjustments to the unadjusted 2016 inventory

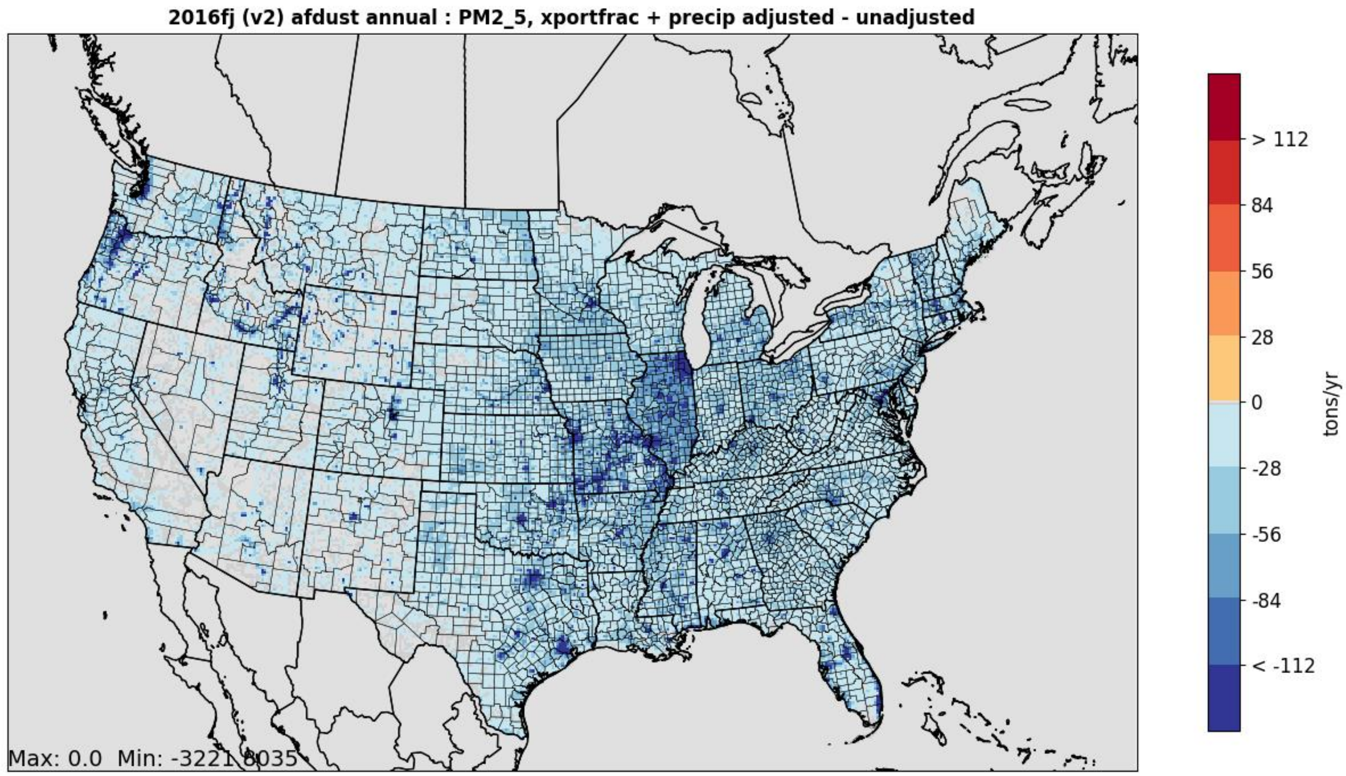
State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
Alabama	301,220	40,516	-206,837	-27,820	69%	69%
Arizona	180,413	24,148	-65,952	-8,640	37%	36%
Arkansas	389,426	53,870	-261,601	-35,627	67%	66%
California	307,525	38,907	-133,858	-16,408	44%	42%
Colorado	276,798	40,283	-138,818	-19,548	50%	49%
Connecticut	24,307	4,007	-18,293	-3,032	75%	76%
Delaware	15,263	2,346	-9,201	-1,422	60%	61%
District of Columbia	2,882	406	-1,804	-253	63%	62%
Florida	390,779	54,511	-208,568	-29,187	53%	54%
Georgia	290,522	41,465	-201,028	-28,482	69%	69%
Idaho	560,472	64,931	-295,880	-33,156	53%	51%
Illinois	1,107,780	159,636	-679,749	-97,634	61%	61%
Indiana	144,272	26,977	-95,341	-17,919	66%	66%
Iowa	385,014	56,805	-222,410	-32,650	58%	57%
Kansas	668,387	88,915	-300,638	-39,593	45%	45%
Kentucky	177,018	28,904	-128,875	-20,989	73%	73%
Louisiana	180,035	27,399	-115,251	-17,368	64%	63%
Maine	71,295	8,735	-59,096	-7,251	83%	83%
Maryland	74,347	11,904	-48,034	-7,748	65%	65%
Massachusetts	61,438	9,379	-47,183	-7,161	77%	76%
Michigan	292,345	38,470	-213,919	-27,925	73%	73%
Minnesota	423,012	59,575	-263,321	-36,486	62%	61%
Mississippi	448,193	54,854	-307,949	-37,331	69%	68%
Missouri	1,319,996	156,248	-858,902	-101,313	65%	65%
Montana	501,655	66,435	-277,120	-35,529	55%	53%
Nebraska	515,575	71,436	-246,621	-33,630	48%	47%
Nevada	138,466	18,305	-45,931	-6,047	33%	33%
New Hampshire	20,527	4,310	-16,979	-3,560	83%	83%
New Jersey	32,466	6,059	-21,778	-4,015	67%	66%
New Mexico	205,161	25,615	-80,428	-9,987	39%	39%
New York	238,564	33,653	-178,529	-25,035	75%	74%

State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
North Carolina	233,349	31,479	-160,106	-21,641	69%	69%
North Dakota	397,407	61,024	-211,752	-32,100	53%	53%
Ohio	273,211	42,880	-182,757	-28,709	67%	67%
Oklahoma	601,218	81,825	-313,021	-41,638	52%	51%
Oregon	605,831	68,330	-404,663	-44,666	67%	65%
Pennsylvania	135,564	24,365	-97,991	-17,891	72%	73%
Rhode Island	4,641	775	-3,308	-551	71%	71%
South Carolina	117,181	16,266	-77,402	-10,817	66%	66%
South Dakota	215,908	38,503	-106,792	-18,757	49%	49%
Tennessee	140,798	25,845	-95,578	-17,651	68%	68%
Texas	1,317,935	190,982	-632,794	-89,482	48%	47%
Utah	165,959	21,202	-84,561	-10,620	51%	50%
Vermont	76,398	8,509	-65,227	-7,237	85%	85%
Virginia	124,875	20,123	-90,751	-14,718	73%	73%
Washington	230,686	37,529	-128,255	-20,829	56%	56%
West Virginia	86,192	11,111	-72,997	-9,417	85%	85%
Wisconsin	182,302	30,984	-124,770	-21,188	68%	68%
Wyoming	542,620	60,863	-272,862	-30,182	50%	50%
Domain Total (12km CONUS)	**15,197,226**	**2,091,599**	**-8,875,481**	**-1,210,842**	**58%**	**58%**
Alaska (v1)	112,025	110,562	-101,822	-10,508	91%	91%
Hawaii (v1)	109,120	11,438	-73,612	-7,673	67%	67%
Puerto Rico (v1)	5,889	1,313	-4,355	-984	74%	75%
Virgin Islands (v1)	3,493	467	-1,477	-195	42%	42%

Figure 2-1 illustrates the impact of each step of the adjustment. The reductions due to the transport fraction adjustments alone are shown at the top of the figure. The reductions due to the precipitation adjustments alone are shown in the middle of the figure. The cumulative emission reductions after both transport fraction and meteorological adjustments are shown at the bottom of the figure. The top plot shows how the transport fraction has a larger reduction effect in the east, where forested areas are more effective at reducing PM transport than in many western areas. The middle plot shows how the meteorological impacts of precipitation, along with snow cover in the north, further reduce the dust emissions.

Figure 2-1. Impact of adjustments to fugitive dust emissions due to transport fraction, precipitation, and cumulative





2.2.2 Agricultural Livestock (livestock)

The livestock sector includes NH3 emissions from fertilizer and emissions of all pollutants other than $PM_{2.5}$ from livestock in the nonpoint (county-level) data category of the 2017NEI. $PM_{2.5}$ from livestock are in the Area Fugitive Dust (afdust) sector. Combustion emissions from agricultural equipment, such as tractors, are in the nonroad sector. The livestock sector includes VOC and HAP VOC in addition to NH3. The 2016v2 and v3 use a 2016 USDA-based county-level back-projection of 2017NEI livestock emissions. The SCCs included in the ag sector are shown in Table 2-10. For 2016v3, corrections were made to the 2016 livestock emissions in Maryland and Illinois. Otherwise, the 2016 livestock emissions in 2016v3 are unchanged from those in 2016v2.

Table 2-10. SCCs for the livestock sector

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805002000	Miscellaneous Area Sources	Ag. Production – Livestock	Beef cattle production composite	Not Elsewhere Classified
2805007100	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - layers with dry manure management systems	Confinement
2805009100	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - broilers	Confinement
2805010100	Miscellaneous Area Sources	Ag. Production – Livestock	Poultry production - turkeys	Confinement
2805018000	Miscellaneous Area Sources	Ag. Production – Livestock	Dairy cattle composite	Not Elsewhere Classified
2805025000	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production composite	Not Elsewhere Classified (see also 28-05-039, -047, -053)

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805035000	Miscellaneous Area Sources	Ag. Production – Livestock	Horses and Ponies Waste Emissions	Not Elsewhere Classified
2805040000	Miscellaneous Area Sources	Ag. Production – Livestock	Sheep and Lambs Waste Emissions	Total
2805045000	Miscellaneous Area Sources	Ag. Production – Livestock	Goats Waste Emissions	Not Elsewhere Classified

The 2016v2 and v3 platform livestock emissions consist of a back-projection of 2017 NEI livestock emissions to the year 2016 and include NH3 and VOC. The livestock waste emissions from 2017 NEI contain emissions for beef cattle, dairy cattle, goats, horses, poultry, sheep, and swine. The data come from both state-submitted emissions and EPA-calculated emission estimates. Further information about the 2017 NEI emissions can be found in the 2017 National Emissions Inventory Technical Support Document (EPA, 2021d). Back-projection factors for 2016 emission estimates are based on animal population data from the USDA National Agriculture Statistics Service Quick Stats (https://www.nass.usda.gov/Quick_Stats). These estimates are developed by data collected from annual agriculture surveys and the Census of Agriculture that is completed every five years. These data include estimates for beef, layers, broilers, turkeys, dairy, swine, and sheep. Each SCC in the 2017 NEI livestock inventory, except for 2805035000 (horses and ponies) and 2805045000 (goats), was mapped to one of these USDA categories. Then, back-projection factors were calculated based on USDA animal populations for 2016 and 2017. Emissions for animal categories for which population data were not available (e.g., horses, goats) were held constant in the projection.

Maryland and Illinois year 2016 livestock emissions in 2016v3 are changed from 2016v2 but otherwise the emissions are the same in both platforms. In Maryland, livestock omissions were discovered in the 2017 NEI. The latest version of the 2017 NEI (January 2021) also includes updated Illinois emissions compared to the earlier version of 2017 NEI, resulting in slightly lower NH3 and significantly lower VOC. The 2016v3 year 2016 inventory is based on a backcast of the improved 2017 Illinois and Maryland emissions.

Back-projection factors were calculated at the county level, but only where county-level data were available for a specific animal category. County-level factors were limited to a range of 0.833 to 1.2. Data were not available for every animal category in every county. State-wide back-projection factors based on state total animal populations were calculated and applied to counties where county-specific data was not available for a given animal category. However, data were often not available for every animal category in every state. For categories other than beef and dairy, data are not available for most states. In cases of missing state-level data, a national back-projection factor was applied. Back-projection factors were not pollutant-specific and were applied to all pollutants. The national back-projection factors, which were only used when county or state data were not available, are shown in Table 2-11. The national factors were created using a ratio between animal inventory counts for 2017 and 2016 from the USDA National livestock inventory projections published in February 2018[4].

[4] https://www.ers.usda.gov/webdocs/outlooks/87459/oce-2018-1.pdf?v=7587.1

Table 2-11. National back-projection factors for livestock: 2017 to 2016

beef	-1.8%
swine	-3.6%
broilers	-2.0%
turkeys	-0.3%
layers	-2.3%
dairy	-0.4%

2.2.3 Agricultural Fertilizer (fertilizer)

Fertilizer emissions for 2016 are based on the Fertilizer Emission Scenario Tool for CMAQ (FEST-C) model (https://www.cmascenter.org/fest-c/). These emissions are for SCC 2801700099 (Miscellaneous Area Sources; Ag. Production – Crops; Fertilizer Application; Miscellaneous Fertilizers). The bidirectional version of CMAQ (v5.3.2) and the Fertilizer Emissions Scenario Tool for CMAQ FEST-C (v1.4) were used to estimate ammonia (NH_3) emissions from agricultural soils. For 2016v3, a correction to the 2016 livestock emissions was implemented by multiplying by 17/14 to reflect the correct molecular weight for NH_3. Otherwise, the fertilizer emissions in 2016v3 are consistent with those in 2016v2.

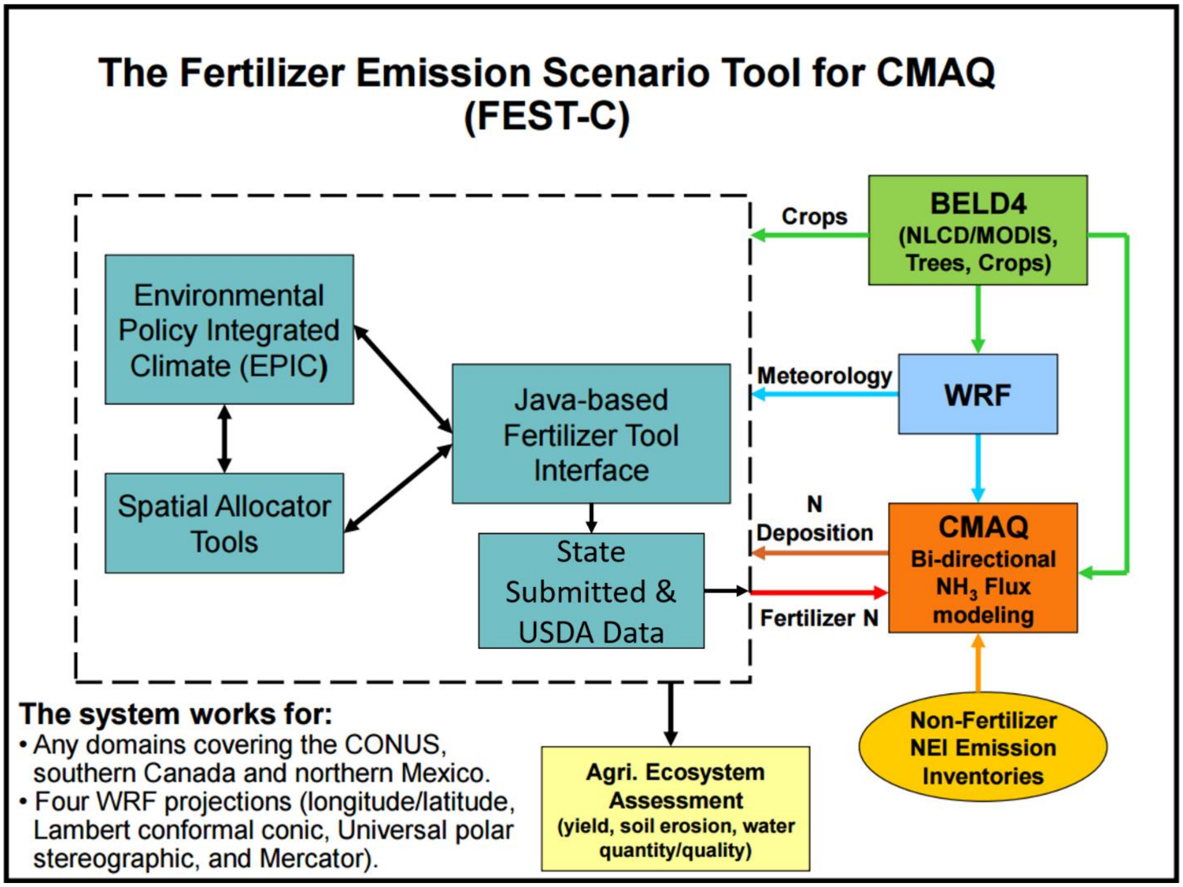
The approach to estimate year-specific fertilizer emissions consists of these steps:

- Run FEST-C to produce nitrate (NO3), Ammonium (NH4+, including Urea), and organic (manure) nitrogen (N) fertilizer usage estimates.
- Run the CMAQ model with bidirectional ("bidi") NH3 exchange to generate gaseous ammonia NH3 emission estimates.
- Calculate county-level emission factors as the ratio of bidirectional CMAQ NH3 fertilizer emissions to FEST-C total N fertilizer application.

FEST-C is the software program that processes land use and agricultural activity data to develop inputs for the CMAQ model when run with bidirectional exchange. FEST-C reads land use data from the Biogenic Emissions Landuse Dataset (BELD), meteorological variables from the Weather Research and Forecasting (WRF) model, and nitrogen deposition data from a previous or historical average CMAQ simulation. FEST-C, then uses the Environmental Policy Integrated Climate (EPIC) modeling system (https://epicapex.tamu.edu/epic/) to simulate the agricultural practices and soil biogeochemistry and provides information regarding fertilizer timing, composition, application method and amount.

An iterative calculation was applied to estimate fertilizer emissions for the 2016 platform. First, fertilizer application by crop type was estimated using FEST-C modeled data. Then CMAQ v5.3 was run with the Surface Tiled Aerosol and Gaseous Exchange (STAGE) deposition option with bidirectional exchange to estimate fertilizer and biogenic NH3 emissions.

Figure 2-2. "Bidi" modeling system used to compute 2016 Fertilizer Application emissions



Fertilizer Activity Data

The following activity parameters were input into the EPIC model:

- Grid cell meteorological variables from WRF
- Initial soil profiles/soil selection
- Presence of 21 major crops: irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g., lettuce, tomatoes, etc.)
- Fertilizer sales to establish the type/composition of nutrients applied
- Management scenarios for the 10 USDA production regions. These include irrigation, tile drainage, intervals between forage harvest, fertilizer application method (injected versus surface applied), and equipment commonly used in these production regions.

The WRF meteorological model was used to provide grid cell meteorological parameters for year 2016 using a national 12-km rectangular grid covering the continental U.S. The meteorological parameters in Table 2-12 were used as EPIC model inputs.

Table 2-12. Source of input variables for EPIC

EPIC input variable	Variable Source
Daily Total Radiation (MJ/m^2)	WRF
Daily Maximum 2-m Temperature (C)	WRF
Daily minimum 2-m temperature (C)	WRF
Daily Total Precipitation (mm)	WRF
Daily Average Relative Humidity (unitless)	WRF
Daily Average 10-m Wind Speed ($m\ s^{-1}$)	WRF
Daily Total Wet Deposition Oxidized N (g/ha)	CMAQ
Daily Total Wet Deposition Reduced N (g/ha)	CMAQ
Daily Total Dry Deposition Oxidized N (g/ha)	CMAQ
Daily Total Dry Deposition Reduced N (g/ha)	CMAQ
Daily Total Wet Deposition Organic N (g/ha)	CMAQ

Initial soil nutrient and pH conditions in EPIC were based on the 1992 USDA Soil Conservation Service (CSC) Soils-5 survey. The EPIC model then was run for 25 years using current fertilization and agricultural cropping techniques to estimate soil nutrient content and pH for the 2016 EPIC/WRF/CMAQ simulation.

The presence of crops in each model grid cell was determined using USDA Census of Agriculture data (2012) and USGS National Land Cover data (2011). These two data sources were used to compute the fraction of agricultural land in a model grid cell and the mix of crops grown on that land.

Fertilizer sales data and the 6-month period in which they were sold were extracted from the 2014 Association of American Plant Food Control Officials (AAPFCO, http://www.aapfco.org/publications.html). AAPFCO data were used to identify the composition (e.g., urea, nitrate, organic) of the fertilizer used, and the amount applied is estimated using the modeled crop demand. These data were useful in making a reasonable assignment of what kind of fertilizer is being applied to which crops.

Management activity data refers to data used to estimate representative crop management schemes. The USDA Agricultural Resource Management Survey (ARMS, https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Ag_Resource_Management/) was used to provide management activity data. These data cover 10 USDA production regions and provide management schemes for irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g., lettuce, tomatoes, etc.).

2.2.4 Nonpoint Oil and Gas (np_oilgas)

While the major emissions sources associated with oil and gas collection, processing, and distribution have traditionally been included in the National Emissions Inventory (NEI) as point sources (e.g., gas processing plants, pipeline compressor stations, and refineries), the activities occurring "upstream" of these types of facilities have not been as well characterized in the NEI. Here, upstream activities refer to emission units and processes associated with the exploration and drilling of oil and gas wells, and the equipment used at the wellsite to then extract the product from the well and deliver it to a central collection point or processing facility. The types of unit processes found at upstream sites include separators, dehydrators, storage tanks, and compressor engines.

The nonpoint oil and gas (np_oilgas) sector, which consists of oil and gas exploration and production sources, both onshore and offshore (state-owned only). For many states, these emissions are mostly based on the EPA Oil and Gas Tool run with data specific to the year 2016, while some states submitted their own inventory data. For 2016v3, updates were made to 2016 np_oilgas emissions in Colorado, Oklahoma, and Texas in response to comments. Because of the growing importance of these emissions, special consideration is given to the speciation, spatial allocation, and monthly temporalization of nonpoint oil and gas emissions, instead of relying on older, more generalized profiles.

EPA Oil and Gas Tool

EPA developed the 2016 non-point oil and gas inventory for the 2016v2 and v3 platform using the 2017NEI version of the Oil and Gas Emission Estimation Tool (the "Tool") with year 2016 oil and gas production and exploration activity as input into the Tool. The Tool was previously used to estimate emissions for the 2017 NEI. Year 2016 oil and gas activity data were supplied to EPA by some state air agencies, and where state data were not supplied to EPA, EPA populated the 2016v2 inventory with the best available data. The Tool is an Access database that utilizes county-level activity data (e.g., oil production and well counts), operational characteristics (types and sizes of equipment), and emission factors to estimate emissions. The Tool creates a CSV-formatted emissions dataset covering all national nonpoint oil and gas emissions. This dataset is then converted to FF10 format for use in SMOKE modeling. A separate report named "2017 Nonpoint Oil and Gas Emission Estimation Tool Revisions_V1 4_11_2019.docx" (ERG, 2019a) was generated that provides technical details of how the tool was applied for the 2017NEI. This 2017 NEI Tool document can be found at: https://gaftp.epa.gov/air/nei/2017/doc/supporting_data/nonpoint/.

Nonpoint Oil and Gas Alternative Datasets

Some states provided, or recommended use of, a separate emissions inventory for use in 2016v2 platform instead of emissions derived from the EPA Oil and Gas Tool. For example, the California Air Resources Board (CARB) developed their own np_oilgas emissions inventory for 2016 for California that were used for the 2016v1, v2, and v3 platforms.

In Pennsylvania for the 2016v2 and 2016v3 modeling platform, the emissions associated with unconventional wells for year 2016 were supplied by the Pennsylvania Department of Environmental Protection (PA DEP). The Oil and Gas Tool was used to produce the conventional well emissions for 2016. Together these unconventional and conventional well emissions represent the total non-point oil and gas emissions for Pennsylvania.

A major update in 2016v2 was the incorporation of the WRAP oil and gas inventory, which is described in more detail below and in the WRAP Final report (WRAP / Ramboll, 2019). Specifically, production-related emissions from the WRAP inventory were used, along with the exploration-related emissions from the 2017NEI Oil and Gas Tool for the following states: CO, MT, ND, NM, SD, UT, and WY. The exploration-related emissions were used from the Tool because they likely better align with exploration activity in year 2016 vs the WRAP 2014 inventory which better represented exploration activity for year 2014.

The changes made to 2016v3 year 2016 np_oilgas emissions as compared to 2016v2 are:

- Use the 2016v1 emissions for Colorado production and exploration and continue using the WRAP spatial surrogates per Colorado's request.
- Use the 2016v1 emission for Texas production-related sources and use 2016v2 emissions for exploration-relate sources.
- Use 2017 NEI data for Oklahoma production-related sources and use 2016v2 emissions for exploration-related sources.

2.2.5 Residential Wood Combustion (rwc)

The RWC sector includes residential wood burning devices such as fireplaces, fireplaces with inserts, free standing woodstoves, pellet stoves, outdoor hydronic heaters (also known as outdoor wood boilers), indoor furnaces, and outdoor burning in firepits and chimneys. Free standing woodstoves and inserts are further differentiated into three categories: 1) conventional (not EPA certified); 2) EPA certified, catalytic; and 3) EPA certified, noncatalytic. Generally, the conventional units were constructed prior to 1988. Units constructed after 1988 had to meet EPA emission standards and they are either catalytic or non-catalytic. The source classification codes (SCCs) in the RWC sector are listed in Table 2-13. For 2016v3, the 2016 rwc emissions for Idaho were replaced with those from the 2017 NEI, but otherwise the emissions are unchanged from 2016v2.

Table 2-13. 2016 v1 platform SCCs for the residential wood combustion sector

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2104008100	Stationary Source Fuel Combustion	Residential	Wood	Fireplace: general
2104008210	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; non-EPA certified
2104008220	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; EPA certified; non-catalytic
2104008230	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: fireplace inserts; EPA certified; catalytic
2104008310	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, non-EPA certified
2104008320	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, EPA certified, non-catalytic
2104008330	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: freestanding, EPA certified, catalytic

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2104008400	Stationary Source Fuel Combustion	Residential	Wood	Woodstove: pellet-fired, general (freestanding or FP insert)
2104008510	Stationary Source Fuel Combustion	Residential	Wood	Furnace: Indoor, cordwood-fired, non-EPA certified
2104008610	Stationary Source Fuel Combustion	Residential	Wood	Hydronic heater: outdoor
2104008700	Stationary Source Fuel Combustion	Residential	Wood	Outdoor wood burning device, NEC (fire-pits, chimneas, etc)
2104009000	Stationary Source Fuel Combustion	Residential	Firelog	Total: All Combustor Types

For all states except Idaho, rwc emissions from the 2017NEI were backcast to 2016 using a single projection factor (+3.254%) based on data from EIA/SEDS. Thus, rwc emissions are the same for 2016v2 and v3, with the exception of Idaho where 2017 NEI emissions were used.

2.2.6 Solvents (np_solvents)

The np_solvents sector is a diverse collection of emission sources for which emissions are driven by evaporation. Included in this sector are everyday items such as cleaners, personal care products, adhesives, architectural and aerosol coatings, printing inks, and pesticides. These sources exclusively emit organic gases (i.e., VOCs) with origins spanning residential, commercial, institutional, and industrial settings. The organic gases that evaporate from these sources often fulfill other functions than acting as a traditional solvent (e.g., propellants, fragrances, emollients); as such, these emissions are frequently described as volatile chemical products (VCPs). In the 2016v2 and 2016v3 platforms, these products comprise the np_solvents sector. For 2016v3, updates to the methodology used to compute emissions in the np_solvents sector were implemented

The types of sources in the np_solvents sector include, but are not limited to, solvent utilization for the following:

- surface coatings such as architectural coatings, auto refinishing, traffic marking, textile production, furniture finishing, and coating of paper, plastic, metal, appliances, and motor vehicles;
- degreasing of furniture, metals, auto repair, electronics, and manufacturing;
- dry cleaning, graphic arts, plastics, industrial processes, personal care products, household products, adhesives and sealants; and
- asphalt application, roofing asphalt, and pesticide application.

For the 2016v3 platform, emissions for the np_solvents sector are derived using the VCPy framework (Seltzer et al., 2021). The VCPy framework is based on the principle that the magnitude and speciation of organic emissions from this sector are directly related to (1) the mass of chemical products used, (2) the composition of these products, (3) the physiochemical properties of their constituents that govern volatilization, and (4) the timescale available for these constituents to evaporate. National product usage is preferentially estimated using economic statistics from the U.S. Census Bureau's Annual Survey of Manufacturers (U.S. Census Bureau, 2021), commodity prices from the U.S. Department of

Transportation's 2012 Commodity Flow Survey (U.S. Department of Transportation, 2015) and the U.S. Census Bureau's Paint and Allied Products Survey (U.S. Census Bureau, 2011), and producer price indices, which scale commodity prices to target years, are retrieved from the Federal Reserve Bank of St. Louis (U.S. Bureau of Labor Statistics, 2020).

In circumstances in which data are unavailable, default usage estimates were derived using functional solvent usage reported by a business research company (The Freedonia Group, 2016) or in sales reported in a California Air Resources Board (CARB) California-specific survey (CARB, 2019). The composition of products is estimated by generating composites from various CARB surveys (CARB, 2007; CARB, 2012; CARB 2014; CARB, 2018; CARB, 2019) and profiles reported in the U.S. EPA's SPECIATE database (EPA, 2019). The physiochemical properties of all organic components are generated from the quantitative structure-activity relationship model OPERA (Mansouri et al., 2018) and the characteristic evaporation timescale of each component is estimated using previously published methods (Khare and Gentner, 2018; Weschler and Nazaroff, 2008).

National-level emissions were allocated to the county-level using several proxies. Most emissions are allocated using population as an allocation surrogate. This includes all cleaners, personal care products, adhesives, architectural coatings, and aerosol coatings. Industrial coatings, allied paint products, printing inks, and dry-cleaning emissions are allocated using county-level employment statistics from the U.S. Census Bureau's County Business Patterns (U.S. Census Bureau, 2018) and follow the same mapping scheme used in the EPA's 2017 National Emissions Inventory (EPA, 2021d). Agricultural pesticides are allocated using county-level agricultural pesticide use, as taken from the 2017 NEI and traffic marking coatings are allocated using estimates of vehicular lane miles traveled on paved roads from the Federal Highway Administration and MOVES model. All activity data reflects the most recently available dataset.

Unlike the 2016v2 modeling platform, the 2016v3 reconciles point and nonpoint emissions for which SCCs overlap using point source subtraction. Point source subtraction was performed at the county-level using estimates of uncontrolled point source emissions. Uncontrolled point source emission calculations were calculated, as necessary, using the submitted point source emissions, engineering judgement, and an assumed control efficiency.

In addition, methodological updates to the underlying nonpoint solvents model made since the release of the 2016v2 modeling platform were incorporated in 2016v3 to make the methods consistent with those used to estimate emissions for the 2020 NEI. These updates include: (1) indoor usage assumptions at the product-level to modulate evaporation characteristics, and (2) control assumptions for select states that have implemented reduction strategies for select consumer and commercial products, as well as architectural and industrial maintenance coatings. Details for all methodology can be found in the Nonpoint Emissions Methodology and Operator Instructions (NEMO) document for the 2020 NEI.

Finally, remaining updates made in response to comments include: (1) reintroduction of all asphalt paving emissions from the 2017 NEI, (2) reintroduction of non-VOC CAPs and HAPs that were not included in the 2016v2 modeling platform but are included in the 2017 NEI, (3) reintroduction of CAP and HAP emissions for the SCCs 2440020000, 2401010000, 2440000000, 2461023000, 2461800001, 2461800002, 2401050000, 2401045000, 2401035000, 2461000000, and 2461160000, all of which were not included in the 2016v2 modeling platform but were included in the 2017 NEI, and (4) removal of emissions from 2420000000 and 2425000000 from Colorado, per Colorado's request to avoid double counting.

2.2.7 Nonpoint (nonpt)

The starting points for the 2016v3 nonpt inventories is the 2017 NEI. The nonpt sector includes all nonpoint sources that are not included in the sectors afdust, livestock, fertilizer, cmv_c1c2, cmv_c3, np_oilgas, rail, rwc, or np_solvents. The types of sources in the nonpt sector include, but are not limited to:

- stationary source fuel combustion, including industrial, commercial, and residential and orchard heaters;
- commercial sources such as commercial cooking;
- industrial processes such as chemical manufacturing, metal production, mineral processes, petroleum refining, wood products, fabricated metals, and refrigeration;
- storage and transport of petroleum for uses such as gasoline service stations, aviation, and marine vessels;
- storage and transport of chemicals;
- waste disposal (including composting);
- miscellaneous non-industrial sources such as cremation, hospitals, lamp breakage, and automotive repair shops;
- bulk gasoline terminals;
- portable gas cans;
- cellulosic biorefining;
- biomass fuel combustion;
- stage 1 refueling emissions at gas stations;
- and any construction agricultural dust or waste that is not part of the afdust or livestock sectors.

For 2016v3, all emissions in nonpt were taken from 2017 NEI, although some for some SCCs adjustments were applied to reflect 2016 levels. For biomass fuel combustion, 2017 NEI data were backcast to 2016 by applying a 4.27% reduction for industrial emissions and a 0.15% reduction for commercial emissions. Refueling emissions at gas stations in the nonpt sector were interpolated to 2016 between 2002 NEI and 2017 NEI levels.

The use of 2017 NEI for nonpt replaced the overrides that were needed for the 2016v2 and 2016v1 platforms, including removal of emissions for SCCs for Industrial (2102004000) and Commercial/Institutional (2103004000) Distillate Oil, Total: Boilers and Internal Combustion (IC) Engines in New Jersey and removal of Industrial, Commercial, Institutional (ICI) Wood emissions (2102008000) PM2.5 emissions in Alabama. in the beta version of this emissions modeling platform and were significantly higher than other states' ICI Wood emissions, be removed from 2016v1 platform

2.3 2016 Onroad Mobile sources (onroad)

Onroad mobile source include emissions from motorized vehicles operating on public roadways. These include passenger cars, motorcycles, minivans, sport-utility vehicles, light-duty trucks, heavy-duty trucks, and buses. The sources are further divided by the fuel they use, including diesel, gasoline, E-85, and compressed natural gas (CNG) vehicles. The sector characterizes emissions from parked vehicle processes (e.g., starts, hot soak, and extended idling) as well as from on-network processes (i.e., from vehicles as they move along the roads). Except for California, all onroad emissions are generated using the SMOKE-MOVES emissions modeling framework that leverages MOVES-generated emission factors, county and SCC-specific activity data, and hourly meteorological data. The onroad source classification codes (SCCs) in the modeling platform are more finely resolved than those in the National Emissions Inventory (NEI). The NEI SCCs distinguish vehicles and fuels. The SCCs used in the modeling platform also distinguish between emissions processes (i.e., off-network, on-network, and extended idle), and road types. For 2016v3, updates from 2016v2 consisted of updated activity data for starts in 20 Georgia counties; corrected road type distributions and hoteling for Florida, Illinois, Minnesota, Missouri, South Carolina, and West Virginia; and corrected emission factors for combination long haul trucks nationwide.

Onroad emissions were computed with SMOKE-MOVES by multiplying appropriate vehicle activity data by the corresponding emission factors for the process. This section includes discussions of the activity data and the emission factor development. The vehicles (aka source types) for which MOVES3 computes emissions are shown in Table 2-14. SMOKE-MOVES was run for specific modeling grids. Emissions for the contiguous U.S. states and Washington, D.C., were computed for a grid covering those areas. For the 2016v1 platform, missions for Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands were computed by running SMOKE-MOVES for distinct grids covering each of those regions and are included in the onroad_nonconus sector. In some summary reports these non-CONUS emissions are aggregated with emissions from the onroad sector. Onroad emissions computations outside of the contiguous U.S. were not updated in the 2016v2 or 2016v3 platforms.

Table 2-14. MOVES vehicle (source) types

MOVES vehicle type	Description	HPMS vehicle type
11	Motorcycle	10
21	Passenger Car	25
31	Passenger Truck	25
32	Light Commercial Truck	25
41	Other Bus	40
42	Transit Bus	40
43	School Bus	40
51	Refuse Truck	50
52	Single Unit Short-haul Truck	50
53	Single Unit Long-haul Truck	50
54	Motor Home	50
61	Combination Short-haul Truck	60
62	Combination Long-haul Truck	60

2.3.1 Onroad Activity Data Development

SMOKE-MOVES uses vehicle miles traveled (VMT), vehicle population (VPOP), vehicle starts, hours of off-network idling (ONI), and hours of hoteling, to calculate emissions. These datasets are collectively known as "activity data". For each of these activity datasets, first a national dataset was developed; this national dataset is called the "EPA default" dataset. The default dataset started with the 2017 NEI activity data, which was then scaled back to 2016 using Federal Highway Administration (FHWA) VM-2 trends. Second, data submitted by state and local agencies were incorporated where available, in place of the EPA default data. EPA default activity was used for California, but the emissions were scaled to California-supplied values during the emissions processing. The agencies for which 2016 submitted data, or 2017 submitted VMT and VPOP data backcast to 2016, were used for the 2016v2 and v3 platforms are shown in Table 2-15. The 2017 NEI submissions are shown table to indicate states for which the 2016 data were backcast from 2017 NEI activity data, in the event that no 2016-specific data were submitted.

Table 2-15. Submitted data used to prepare 2016v2 onroad activity data

Agency	2016 VMT	2016 VPOP	2017 NEI
Alaska			yes
Arizona – Maricopa			yes
Arizona – Pima	yes	yes	yes
Colorado	yes	yes	
Connecticut	yes	yes	yes
Delaware			yes
District of Columbia			yes
Florida			yes
Georgia	yes	yes	yes
Idaho			yes
Illinois - Chicago area	yes	yes	
Illinois - rest of state	yes	yes	yes
Indiana - Louisville area	yes		
Kentucky – Jefferson	yes	yes	yes
Kentucky - Louisville exurbs	yes		
Maine			yes
Maryland	yes	yes	yes
Massachusetts	yes	yes	yes
Michigan - Detroit area	yes	yes	
Michigan - rest of state	yes	yes	yes
Minnesota	yes	yes	yes
Missouri			yes
Nevada – Clark	yes	yes	yes
Nevada – Washoe			yes
New Hampshire	yes	yes	yes
New Jersey	yes	yes	yes
New York			yes
North Carolina	yes	yes	yes
Ohio			yes
Pennsylvania	yes	yes	yes
Rhode Island			yes
South Carolina	yes	yes	yes
Tennessee – Davidson			yes
Tennessee – Knox			yes

Agency	2016 VMT	2016 VPOP	2017 NEI
Texas			yes
Vermont			yes
Virginia	yes	yes	yes
Washington			yes
West Virginia	yes	yes	yes
Wisconsin	yes	yes	yes

Vehicle Miles Traveled (VMT)

VMT data specific to 2016 were used where states provided it, and for the remaining states, 2016 VMT data were backcast from 2017 NEI data. To compute default 2016 data for states that did not provide 2016-specific data, EPA backcast the 2017 NEI VMT (including state submitted 2017 data) to 2016. The 2017 NEI Technical Support Document has details on the development of the 2017 VMT (EPA, 2021d). The factors to adjust VMT from 2017 to 2016 were based on VMT data from the FHWA county-level VM-2 reports similar to the state-level reports at https://www.fhwa.dot.gov/policyinformation/statistics/2016/vm2.cfm and https://www.fhwa.dot.gov/policyinformation/statistics/2017/vm2.cfm. For most states, EPA calculated county-road type adjustment factors based on FHWA VM-2 County data for 2017 and 2016. Separate adjustment factors were calculated by vehicle type for each of the four MOVES road types. Some states have a very different distribution of urban activity versus rural activity between 2017NEI and the FHWA data, due to inconsistencies in the definition of urban versus rural between the data sets. For those counties, a single county-wide projection factor based on total FHWA VMT across all road types was applied to all VMT independent of road type. County-total-based (instead of county+road-type) factors were used for all counties in IN, MS, MO, NM, TN, TX, and UT because many counties had large increases in one particular road type and decreases in another road type. State-total-based factors were used for all counties in Alaska and Puerto Rico because county level data were questionable. Note that Alaska and Hawaii emissions have not yet been recomputed using MOVES3-based emission factors. State total differences between the 2017 NEI and 2016 VMT data for all states are provided in Table 2-16.

Table 2-16. State total differences between 2017 NEI and 2016 VMT data

State	2017 NEI-2016 %	State	2017 NEI-2016 %
Alabama	2.1%	Montana	0.4%
Alaska	4.9%	Nebraska	1.5%
Arizona	0.5%	Nevada	-4.6%
Arkansas	1.8%	New Hampshire	1.6%
California	1.1%	New Jersey	0.8%
Colorado	2.3%	New Mexico	6.4%
Connecticut	0.6%	New York	1.3%
Delaware	2.8%	North Carolina	-0.2%
District of Columbia	2.5%	North Dakota	-0.2%
Florida	-8.4%	Ohio	0.7%
Georgia	4.2%	Oklahoma	0.8%
Hawaii	1.1%	Oregon	0.0%

Idaho	0.5%	Pennsylvania	0.3%
Illinois	-0.8%	Rhode Island	-2.7%
Indiana	-1.5%	South Carolina	0.9%
Iowa	0.4%	South Dakota	2.0%
Kansas	0.5%	Tennessee	1.4%
Kentucky	0.2%	Texas	7.0%
Louisiana	0.1%	Utah	0.5%
Maine	-0.7%	Vermont	0.1%
Maryland	1.6%	Virgin Islands	0.5%
Massachusetts	5.5%	Virginia	0.0%
Michigan	1.0%	Washington	2.1%
Minnesota	1.9%	West Virginia	0.7%
Mississippi	0.3%	Wisconsin	2.3%
Missouri	2.5%	Wyoming	2.2%

For the 2016 platforms, VMT data submitted by state and local agencies were incorporated and used in place of EPA defaults. Note that VMT data need to be provided to SMOKE for each county and SCC. The onroad SCCs characterize vehicles by MOVES fuel type, vehicle (aka source) type, emissions process, and road type. Any VMT provided at a different resolution than this were converted to a full county-SCC resolution to prepare the data for processing by SMOKE. Details the on pre-processing of submitted VMT and VPOP are provided in the TSD Preparation of Emissions Inventories for the 2016v1 North American Emissions Modeling Platform (EPA, 2021c). Some of the provided data were adjusted following quality assurance, as described below in the VPOP section.

To ensure consistency in the 21/31/32 splits across the country, all state-submitted VMT for MOVES vehicle types 21, 31, and 32 (all of which are part of HPMS vehicle type 25) was summed, and then re-split using the 21/31/32 splits from the EPA 2016v2 default VMT. VMT for each source type as a percentage of total 21/31/32 VMT was calculated by county from the EPA default VMT. Then, state-submitted VMT for 21/31/32 were summed and then re-split according to those percentages. This was done for all states and counties listed above which submitted VMT for 2016. Most of the states listed above did not provide VMT down to the source type, so splitting the light-duty vehicle VMT does not create an inconsistency with state-provided data in those states. Exceptions are New Hampshire and Pennsylvania: those two states provided SCC-level VMT, but these were reallocated to 21/31/32 so that the splits are performed in a consistent way across the country. The 21/31/32 splits in the EPA default VMT are based on the 2017 NEI VPOP data obtained from IHS-Polk through the Coordinating Research Council (CRC) A-115 project (CRC, 2019).

For 2016v3, total 2016 VMT is unchanged from 2016v2. However, road type distributions were updated to be consistent with those in 2020 NEI in Florida, Illinois, Minnesota, Missouri, South Carolina, and West Virginia to correct anomalies found in the 2016v1 and 2016v2 data.

Speed Activity (SPEED/SPDIST)

In SMOKE 4.7, SMOKE-MOVES was updated to use speed distributions similarly to how they are used when running MOVES in inventory mode. This new speed distribution file, called SPDIST, specifies the amount of time spent in each MOVES speed bin for each county, vehicle (aka source) type, road type, weekday/weekend, and hour of day. This file contains the same information at the same resolution as the Speed Distribution table used by MOVES but is reformatted for SMOKE. Using the SPDIST file results in a SMOKE emissions calculation that is more consistent with MOVES than the old hourly speed profile (SPDPRO) approach, because emission factors from all speed bins can be used, rather than interpolating between the two bins surrounding the single average speed value for each hour as is done with the SPDPRO approach.

As was the case with the previous SPDPRO approach, the SPEED inventory that includes a single overall average speed for each county, SCC, and month, must still be read in by the SMOKE program Smkinven. SMOKE requires the SPEED dataset to exist even when speed distribution data are available, even though only the speed distribution data affects the selection of emission factors. The SPEED and SPDIST datasets are carried over from 2017NEI and are based on a combination of the CRC A-100 (CRC, 2017) project data and 2017 NEI MOVES CDBs. There were no changes to the speed activity from 2016v2 to 2016v3.

Vehicle Population (VPOP)

The EPA default VPOP dataset was developed similarly to the default VMT dataset described above. In the areas where we backcast 2017 NEI VMT:

2016v2 VPOP = 2016v2 VMT * (VPOP/VMT ratio by county-SCC6).

where the ratio by county-SCC is based on 2017NEI with MOVES3 fuel splits. In the areas where 2016v1 used VMT re-split to MOVES3 fuels, 2016v3 VPOP = 2016v2 = 2016v1 VPOP with two re-splits: First, source types 21/31/32 were re-split according to 2017 NEI EPA default county-specific 21/31/32 splits so that the whole country has consistent 21/31/32 splits. Next, fuels were re-split to MOVES3 fuels. There are some areas where 2016 VMT was submitted but 2016 VPOP was not; those areas use the 2016v1 VPOP (with re-splits). The same method was applied to the 2016 EPA default VMT to produce an EPA default VPOP data set. There were no changes to the VPOP from 2016v2 to v3.

Hoteling Hours (HOTELING)

Hoteling hours activity data are used to calculate emissions from extended idling and auxiliary power units (APUs) for heavy duty diesel vehicles. Previously, states have commented that EPA estimates of hoteling hours, and therefore emissions resulting from hoteling, are higher than they could be in reality given the available parking spaces in some places. Therefore, recent hoteling activity datasets, including the 2016v1, v2, and v3 platforms, incorporate reductions to hoteling activity data based on the availability of truck stop parking spaces in each county, as described below. Starting with 2016v1, hoteling hours were recomputed using a new factor identified by EPA's Office of Transportation and Air Quality as more appropriate based on recent studies.

The method used is the following:

- Start with 2016 VMT for source type 62 on restricted roads, by county.
- Multiply that by 0.007248 hours/mile (EPA, 2020). (Note that this results in about 73.5% less hoteling hours as compared to the 2014NEIv2 approach.)

- Apply parking space reductions to keep hoteling within the estimated maximum hours by county, except for states that requested we not do that (CO, ME, NJ, NY).

Hoteling hours were adjusted down in counties for which there were more hoteling hours assigned to the county than could be supported by the known parking spaces. To compute the adjustment, the hoteling hours for the county were computed using the above method, and then reductions were applied to the 2016 hoteling hours based on known parking space availability so that there were not more hours assigned to the county than the available parking spaces could support if they were full every hour of every day of the year.

A dataset of truck stop parking space availability with the total number of parking spaces per county was used in the computation of the adjustment factors. This same dataset is used to develop the spatial surrogate for hoteling emissions. For the 2016v1 platform, the parking space dataset included several updates compared to 2016beta platform, based on information provided by some states (e.g., MD). Since there are 8,784 hours in the year 2016; the maximum number of possible hoteling hours in a particular county is equal to 8,784 * the number of parking spaces in that county. Hoteling hours for each county were capped at that theoretical maximum value for 2016 in that county, with some exceptions as outlined below. The parking space dataset used in the hoteling hour computations was unchanged in 2016v2 and 2016v3.

Because the truck stop parking space dataset may be incomplete in some areas, and trucks may sometimes idle in areas other than designated spaces, it was assumed that every county has at least 12 parking spaces, even if fewer parking spaces are found in the parking space dataset. Therefore, hoteling hours are never reduced below 105,408 hours for the year in any county. If the unreduced hoteling hours were already below that maximum, the hours were left unchanged; in other words, hoteling activity are never increased as a result of this analysis.

A handful of high activity counties that would otherwise be subject to a large reduction were analyzed individually to see if their parking space count seemed unreasonably low. In the following counties, the parking space count and/or the reduction factor was manually adjusted:

- 17043 / DuPage IL (instead of reducing hoteling by 84%, applied no adjustment)
- 39061 / Hamilton OH (parking spot count increased to 20 instead of the minimum 12)
- 47147 / Robertson TN (parking spot count increased to 52 instead of just 26)
- 51015 / Augusta VA (parking space count increased to 48 instead of the minimum 12)
- 51059 / Fairfax VA (parking spot count increased to 20 instead of the minimum 12)

Some state-specific hoteling hours data and methods were applied in the 2016 platforms:

- Georgia and New Jersey submitted hoteling activity for the 2016v1 platform, which was carried through into the 2016v2 and v3 platforms along with incorporating an updated APU factor for 2016 based on MOVES3. For these states, the EPA default hoteling hours were replaced with their state data. New Jersey provided their hoteling activity in a series of HotellingHours MOVES-formatted tables, which include separate activity for weekdays and weekends and for each month and which have units of hours-per-week. These data were converted to annual totals by county so they could be used.

- Alaska Department of Natural Resources staff requested that hoteling activity be set to zero in several counties due to the nature of driving patterns in their region.
- There are no hoteling hours or other emissions from long-haul combination trucks in Hawaii, Puerto Rico, or the Virgin Islands.
- The states of Colorado, Maine, New Jersey, and New York requested that no reductions be applied to the hoteling activity based on parking space availability. For these states, we no reductions were applied based on parking space availability and in the case of New Jersey, their submitted activity data were unchanged.

Finally, the county total hoteling was split into separate values for extended idling (SCC 2202620153) and APUs (SCC 2202620191). Compared to earlier versions of MOVES, APU percentages have been lowered for MOVES3. A 5.19% APU split was used for the year 2016, meaning that APUs are used for 5.19% of the hoteling hours. This APU percentage was applied nationwide, including in states where hoteling activity was submitted.

For 2016v2, hoteling was calculated as: 2016v2 HOTELING = 2017NEI HOTELING * 2016v2 VMT/2017NEI VMT. This is effectively consistent with applying the 0.007248 factor directly to the 2016v2 VMT. Then, for counties that provided 2017 hoteling but did not have vehicle type 62 restricted VMT in 2016 – that is, counties that should have hoteling, but do not have any VMT to calculate it from – the 2017 hoteling was backcast to 2016 using the FHWA-based county total 2017 to 2016 trend. Finally, the annual parking-space-based caps for hoteling hours were applied as described above. The same caps were used as for 2017NEI, except recalculated for a leap year (multiplied by 366/365).

For the 2016v3, road type distributions and/or hoteling were adjusted in states where there was hoteling in every county in the state: FL, IL, MN, MO, SC, and WV. 2016v2 VMT in those six states was redistributed by road type based on 2020 NEI road type distributions (by county/vehicle, with county/HPMS filling in where a county/vehicle isn’t available in 2020 NEI), and then hoteling was recalculated based on the new VMT in those six states using the standard VMT/HOTELING factor and parking space adjustments. Notably, this resulted in an overall increase in hoteling in Missouri, although hoteling is now in fewer counties). Hoteling hours in other states were unchanged between 2016v2 and 2016v3.

Starts

Onroad “start” emissions are the instantaneous exhaust emissions that occur at the engine start (e.g., due to the fuel rich conditions in the cylinder to initiate combustion) as well as the additional running exhaust emissions that occur because the engine and emission control systems have not yet stabilized at the running operating temperature. Operationally, start emissions are defined as the difference in emissions between an exhaust emissions test with an ambient temperature start and the same test with the engine and emission control systems already at operating temperature. As such, the units for start emission rates are instantaneous: grams/start.

MOVES3 uses vehicle population information to sort the vehicle population into source bins defined by vehicle source type, fuel type (gas, diesel, etc.), regulatory class, model year and age. The model uses default data from instrumented vehicles (or user-provided values) to estimate the number of starts for each source bin and to allocate them among eight operating mode bins defined by the amount of time parked ("soak time") prior to the start. Thus, MOVES3 accounts for different amounts of cooling of the engine and emission control systems. Each source bin and operating mode has an associated g/start emission rate. Start emissions are also adjusted to account for fuel characteristics, LD inspection and maintenance programs, and ambient temperatures.

2016 STARTS = 2016 VMT * (2017 STARTS/ 2017 VMT by county&SCC6)

For 2016v3, Georgia Environmental Protection Division provided new weekday activity for starts per day for 20 counties. These new starts were used for the weekdays for those 20 counties, while MOVES default starts/day were used for weekend days. Since annual activity data are required by the FF10 activity file format, the number of starts/day was multiplied by the number of weekdays and weekends in the year to calculate the annual total starts for the 20 counties by county and source type. The starts for light duty vehicle source types 21, 31, and 32 were summed and then re-split between the 21, 31, and 32 sources types based on splits from EPA default activity data, so that 21/31/32 splits are from a consistent data source nationwide. Since George only provided their activity data by county and vehicle type, the 2016v2 splits were used as the basis for distribution of the starts to fuel type and month. Starts outside of Georgia were unchanged in 2016v3 from 2016v2 levels.

Off-network Idling Hours

Off-network idling hours (ONI) activity data were needed to support the computation of ONI emissions with MOVES3. ONI is defined in MOVES as time during which a vehicle engine is running idle and the vehicle is somewhere other than on a roadway, such as in a parking lot, a driveway, or at the side of the road. This engine activity contributes to total mobile source emissions but does not take place on the road network. Examples of when ONI activity occurs include:

- light duty passenger vehicles idling while waiting to pick up children at school or to pick up passengers at the airport or train station,
- single unit and combination trucks idling while loading or unloading cargo or making deliveries, and
- vehicles idling at drive-through restaurants.

Note that ONI does not include idling that occurs on a roadway, such as idling at traffic signals, stop signs, and in traffic—these emissions are included as part of the running and crankcase running exhaust processes on the other road types. ONI also does not include long-duration idling by long-haul combination trucks (hoteling/extended idle), as that type of long duration idling is accounted for in other MOVES processes.

ONI activity hours were calculated based on VMT. For each representative county, the ratio of ONI hours to onroad VMT (on all road types) was calculated using the MOVES ONI Tool by source type, fuel type, and month. These ratios were then multiplied by each county's total VMT (aggregated by source type, fuel type, and month) to obtain hours of ONI activity. There were no changes to the ONI activity data between 2016v2 and 2016v3.

2.3.2 MOVES Emission Factor Table Development

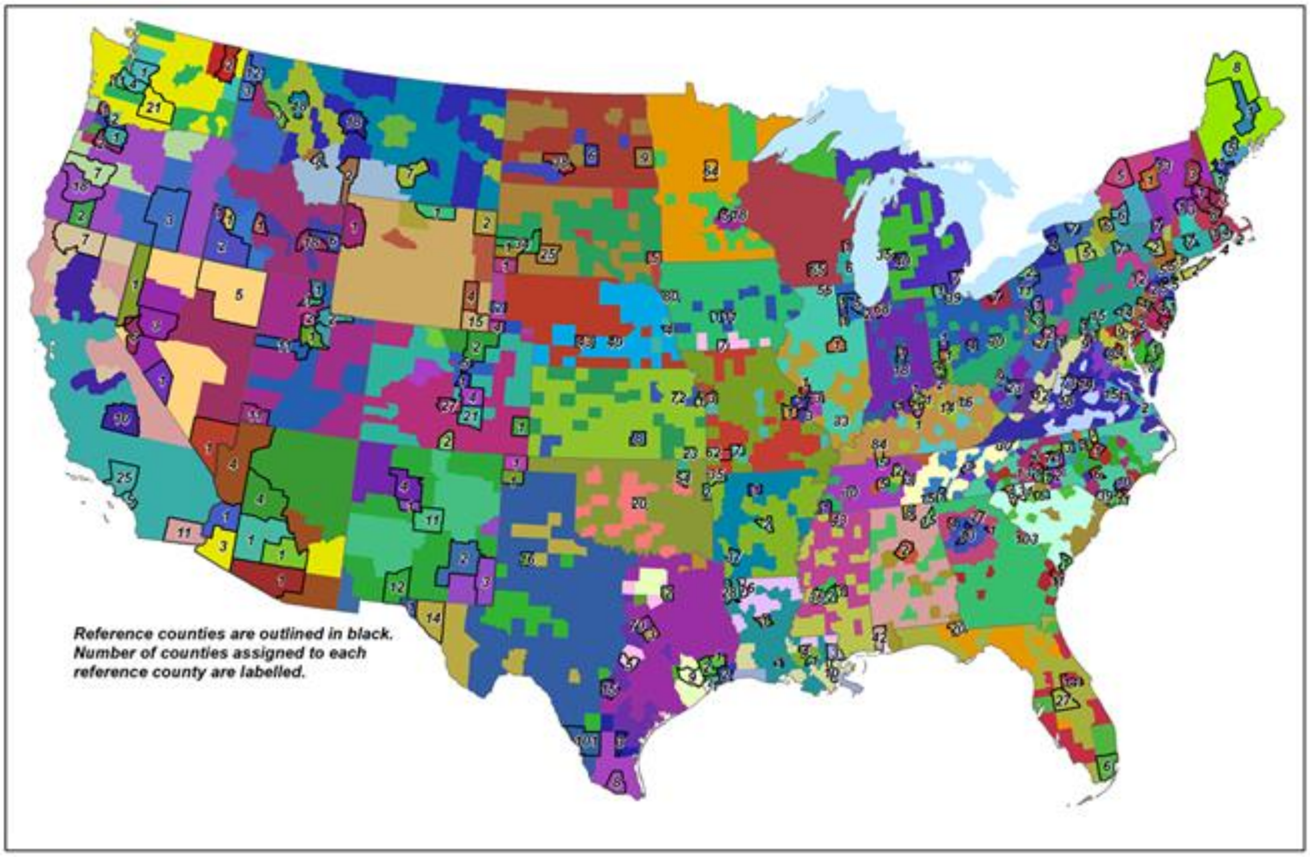
For 2016v2, MOVES3 was run in emission rate mode to create emission factor tables using CB6 speciation for the years 2016, 2023, and 2026, for all representative counties and fuel months. For 2016v3, MOVES3 was rerun for combination trucks to correct an issue with the age distribution for that source type in 2016v2. For 2016v1, MOVES2014b was run for all counties in Alaska, Hawaii, and Virgin Islands, and for a single representative county in Puerto Rico and those emissions were retained in 2016v2 and 2016v3.

The county databases CDBs used to run MOVES3 to develop the emission factor tables were derived from those used for the 2017 NEI and therefore included any updated data provided and accepted for the 2017 NEI process. The 2017 NEI development included an extensive review of the various tables including speed distributions were performed. Where state speed profiles, speed distributions. and temporal profiles data were not accepted from S/L submissions, those data were obtained from the CRC A-100 study. Once the data tables for 2017 NEI were incorporated into the CDBs, a new set of representative counties was developed as part of the EQUATES project for the years 2002-2017 and was slightly expanded for 2016v2.[5] Each county in the continental U.S. was classified according to its state, altitude (high or low), fuel region, the presence of inspection and maintenance programs, the mean light-duty age, and the fraction of ramps. A binning algorithm was executed to identify "like counties", and then specific requests for representative county groups by states for the 2017 NEI were honored. The result was 332 representative counties (up from 315 in 2016v1) as shown in Figure 2-3.
For more information on the development of the 2016 age distributions and representative counties and the review of the input data, see the memoranda "Onroad 2016-23-26-32_Documentation_20210824 _clean.docx" and "CMAQ_Representative_Counties_Analysis_20201009_addFY23-26-32 Parameters.xlsx" (ERG, 2021). There are no changes to representative counties between 2016v2 and 2016v3, although there are some changes for analytic year representative county assignments as noted above and discussed in more detail in Section 4.3.2.

Age distributions are a key input to MOVES in determining emission rates. The base year CDB age distributions were shifted back one year from 2017 to 2016 in all counties so that the recession of 2008-2009 is reflected for the 2008-2009 model years instead of being shifted by one year. The 2016 age distributions were then grown to the analytic years of 2023 and 2026 everywhere except Alaska. Alaska age distributions were not changed in the analytic years because the 2016 distributions did not show a recession dip around model year 2009 and the vehicle populations looked sparse compared to other areas. The age distributions for 2016v2 were updated based on vehicle registration data obtained from the CRC A-115 project, subject to reductions for older vehicles determined according to CRC A-115 methods but using additional age distribution data that became available as part of the 2017 NEI submitted input data. One of the findings of CRC project A-115 was that IHS data contain higher vehicle populations than state agency analyses of the same Department of Motor Vehicles data, and the discrepancies tend to increase with increasing vehicle age (i.e., there are more older vehicles in the IHS data). The CRC project dealt with the discrepancy by releasing datasets based on raw (unadjusted) information and adjusted sets of age distributions, where the adjustments reflected the differences in population by model year of 2014 IHS data and 2014 submitted data from a single state.

[5] One new representative county in Kentucky was added: Kenton County (FIPS code 21117) due to a change for year 2018. Four new representative counties in North Carolina were added for the 2016, 2023, and 2026 runs: 37019, 37159, 37077, and 37135 due to inspection and maintenance programs changing in future years. In addition, one Nebraska county (FIPS code 31115) was moved into a similar group (representative county 31047) due to a small vehicle population and similar mean light-duty vehicle age.

Figure 2-3. Representative Counties in 2016v2 and 2016v3



For the 2017 NEI, and for the 2016v2 platform, EPA repeated the CRC's assessment of IHS vs. state vehicles by age, but with updated information from the 2017 NEI and for more states. The 2017 light-duty vehicle (LDV) populations from the CRC A-115 project were compared by model year to the populations submitted by state/local (S/L) agencies for the 2017 NEI. The comparisons by model year were used to develop adjustment factors that remove older LDVs from the IHS dataset. Out of 31 S/L agencies that provided age distribution and vehicle population data for the 2017 NEI, sixteen agencies provided LDV population and age distributions with snapshot dates of January 2017, July 2017, or 2018. The other fifteen agencies had either unknown or older (e.g., 2013) data pull dates, so were not compared to the 2017 IHS data. The vehicle populations by model year were compared with IHS data for each of the sixteen agencies for source type 21 (passenger cars) and for source type 31 plus 32 (light trucks) together. Prior to finalizing the activity data, the S/L agency populations of passenger cars (source type 21) and light trucks (source types 31 and 21) were matched to IHS car and light-duty truck splits by county so that vehicles of the same model and year were consistently classified into MOVES source types throughout the country. The IHS population of vehicles were found to be higher than the pooled state data by 6.5 percent for cars and 5.9 percent for light trucks.

To adjust for the additional vehicles in the IHS data, vehicle age distribution adjustment factors of one (1) minus the fraction of vehicles to remove from IHS to equal the state data were applied, with two exceptions: (1) the model year range 2007 to 2017 received no adjustment and (2) the model years 1987 and earlier received a capped adjustment that equals the adjustment to 1988. Table 2-17 below shows the fraction of vehicles to keep by model year based on this analysis. The adjustments were applied to the 2016 IHS-based age distributions from CRC project A-115 prior to their use in 2016v1. In addition, the age distributions to ensure the "tail" of the distribution corresponding to age 30 years and older vehicles did not exceed 20% of the fleet. After limiting the age distribution tails, the age distributions were renormalized to ensure they summed to one (1). In addition, antique license plate vehicles were removed based on the registration summary from IHS. Nationally, the prevalence of antique plates is only 0.8 percent, but is as high as 6 percent in some states (e.g., Mississippi).

Table 2-17. Fraction of IHS Vehicle Populations to Retain for 2016v1 and 2017 NEI

Model Year	Cars	Light
pre-1989	0.675	0.769
1989	0.730	0.801
1990	0.732	0.839
1991	0.740	0.868
1992	0.742	0.867
1993	0.763	0.867
1994	0.787	0.842
1995	0.776	0.865
1996	0.790	0.881
1997	0.808	0.871
1998	0.819	0.870
1999	0.840	0.874
2000	0.838	0.896
2001	0.839	0.925
2002	0.864	0.921
2003	0.887	0.942
2004	0.926	0.953
2005	0.941	0.966
2006	1	0.987
2007-2017	1	1

In addition to removing the older and antique plate vehicles from the IHS data, 25 counties found to be outliers because their fleet age was significantly younger than in typical counties. The outlier review was limited to LDV source types 21, 31, and 32. Many rural counties have outliers for low-population source types such as Transit Buses and Refuse Trucks due to small sample sizes, but these do not have much of an impact on the inventory overall and reflect sparse data in low-population areas and therefore do not require correction.

The most extreme examples of LDV outliers were Light Commercial Truck age distributions where over 50 percent of the population in the entire county is 0 and 1 years old. These sorts of young fleets can happen if the headquarters of a leasing or rental company is the owner/entity of a relatively large number of vehicles relative to the county-wide population. While the business owner of thousands of new vehicles may reside in a single county, the vehicles likely operate in broader areas without being registered where they drive. To avoid creating artificial low spots of LDV emissions in these outlier counties, data for all counties with more than 35% new vehicles were excluded from the final set of grouped age distributions that went into the CDBs.

The final year 2016 age distributions were then grouped using a population-weighted average of the source type populations of each county in the representative county group. The resulting end-product was age distributions for each of the 13 source types in each of the 332 representative counties for 2016v2. The long-haul truck source types 53 (Single Unit) and 62 (Combination Unit) are based on a nationwide average due to the long-haul nature of their operation. There were no changes to the age distributions from 2016v2 to v3 except for the recomputation of combination long haul truck age distributions based on data available from the 2020 NEI process.

To create the emission factors for 2016v2, MOVES3 was run separately for each representative county and fuel month and for each temperature bin needed for calendar year 2016. For 2016v3, MOVES was rerun for combination long haul trucks (source type 62) to reflect the updated age distributions and as a result the emissions for source type 62 changed nationwide. The CDBs used to run MOVES include the state-specific control measures such as the California low emission vehicle (LEV) program and the fuels were updated to represent calendar year 2016. In addition, the range of temperatures run along with the average humidities used were specific to the year 2016. The MOVES results were post-processed into CSV-formatted emission factor tables that can be read by SMOKE-MOVES.

2.3.3 Onroad California Inventory Development (onroad_ca)

The California Air Resources Board (CARB) provided their own onroad emissions inventories based on their EMFAC2017 model. EMFAC2017 was run by CARB for the years 2016, 2023, 2028, and 2035. These inventories each include separate totals for on-network and off-network emissions, but they do not include NH_3 or refueling. California emissions were run through SMOKE-MOVES as a separate sector from the rest of the country. The California onroad sector is called "onroad_ca_adj". Changes from 2016v1 include:

- CARB refueling was backcast from 2017NEI to 2016 using MOVES trends, and then SMOKE-MOVES was adjusted to match the backcast refueling.
- California NH_3 was set to MOVES state total NH3, distributed to county-SCC following the distribution of carbon monoxide (CO) as a surrogate for activity.
- For source types other than 62 where CARB provided "idling" emissions, those emissions were mapped to ONI. For source type 62, the CARB-provided "idling" was split between hoteling and ONI. For all other vehicle types (where CARB did not provide "idling" – generally LD vehicles), CARB running exhaust was split between RPD and ONI. Using the updated ONI activity has some effect on distributions of CARB emissions and the non-CARB portion of the emissions (e.g., NH3).

While most source type emission factors used in California remain unchanged from 2016v2, for 2016v3 the newly available emission factors for source type 62 (combination long haul trucks) were used which impacted the emissions of NH_3 and refueling slightly.

2.4 2016 Nonroad Mobile sources (cmv, rail, nonroad)

The nonroad mobile source emission modeling sectors consist of nonroad equipment emissions (nonroad), locomotive (rail), and CMV emissions.

2.4.1 Category 1, Category 2 Commercial Marine Vessels (cmv_c1c2)

The 2016v3 CMV emissions are based on the emissions developed for the 2017 NEI and are the same as those used in the 2016v2 platform, except that for 2016v3 the spatial allocation to county boundaries was improved in response to comments. More specifically, in 2016v3, the CMV emissions were allocated to each county by 1-hour AIS location rather than using the centroid of the grid cell to assign the county in which the emissions occurred. The improvement to county boundary allocation impacts the assignment of the emissions to some counties, such as in the New York-New Jersey area, but the total emissions by model grid cell are unchanged. Sulfur dioxide (SO2) emissions reflect rules that reduced sulfur emissions for CMV that took effect in the year 2015. The cmv_c1c2 inventory sector contains small to medium-size engine CMV emissions. Category 1 and Category 2 (C1C2) marine diesel engines typically range in size from about 700 to 11,000 hp. These engines are used to provide propulsion power on many kinds of vessels including tugboats, towboats, supply vessels, fishing vessels, and other commercial vessels in and around ports. They are also used as stand-alone generators for auxiliary electrical power on many types of vessels. Category 1 represents engines up to 7 liters per cylinder displacement. Category 2 includes engines from 7 to 30 liters per cylinder.

The cmv_c1c2 inventory sector contains sources that traverse state and federal waters along with emissions from surrounding areas of Canada, Mexico, and international waters. The cmv_c1c2 sources are modeled as point sources but using plume rise parameters that cause the emissions to be released in the ground layer of the air quality model.

The cmv_c1c2 sources within state waters are identified in the inventory with the Federal Information Processing Standard (FIPS) county code for the state and county in which the vessel is registered. The cmv_c1c2 sources that operate outside of state waters but within the Emissions Control Area (ECA) are encoded with a state FIPS code of 85. The ECA areas include parts of the Gulf of Mexico, and parts of the Atlantic and Pacific coasts. The cmv_c1c2 sources in the 2016 inventory are categorized as operating either in-port or underway and as main and auxiliary engines are encoded using the SCCs listed in Table 2-18.

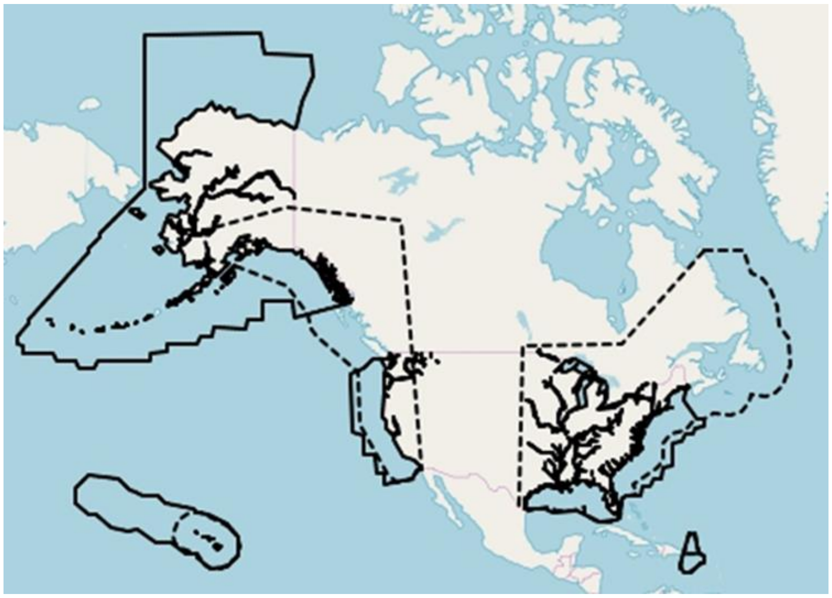
Table 2-18. SCCs for cmv_c1c2 sector

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2280002101	C1/C2	Diesel	Port	Main
2280002102	C1/C2	Diesel	Port	Auxiliary
2280002201	C1/C2	Diesel	Underway	Main
2280002202	C1/C2	Diesel	Underway	Auxiliary

Category 1 and 2 CMV emissions were developed for the 2017 NEI,[6] The 2017 NEI emissions were developed based signals from Automated Identification System (AIS) transmitters. AIS is a tracking system used by vessels to enhance navigation and avoid collision with other AIS transmitting vessels. The USEPA Office of Transportation and Air Quality received AIS data from the U.S. Coast Guard (USCG) in order to quantify all ship activity which occurred between January 1 and December 31, 2017. The provided AIS data extends beyond 200 nautical miles from the U.S. coast (Figure 2-4). This boundary is roughly equivalent to the border of the U.S Exclusive Economic Zone and the North American ECA, although some non-ECA activity are captured as well.

[6] Category 1 and 2 Commercial Marine Vessel 2017 Emissions Inventory (ERG, 2019b).

Figure 2-4. 2017NEI/2016 platform geographical extent (solid) and U.S. ECA (dashed)



The AIS data were compiled into five-minute intervals by the USCG, providing a reasonably refined assessment of a vessel's movement. For example, using a five-minute average, a vessel traveling at 25 knots would be captured every two nautical miles that the vessel travels. For slower moving vessels, the distance between transmissions would be less. The ability to track vessel movements through AIS data and link them to attribute data, has allowed for the development of an inventory of very accurate emission estimates with excellent resolution in time and space. These AIS data were used to define the locations of individual vessel movements, estimate hours of operation, and quantify propulsion engine loads. The compiled AIS data also included the vessel's International Marine Organization (IMO) number and Maritime Mobile Service Identifier (MMSI); which allowed each vessel to be matched to their characteristics obtained from the Clarksons ship registry (Clarksons, 2018).

USEPA used the engine bore and stroke data to calculate cylinder volume. Any vessel that had a calculated cylinder volume greater than 30 liters was incorporated into the USEPA's new Category 3 Commercial Marine Vessel (C3CMV) model. The remaining records were assumed to represent Category 1 and 2 (C1C2) or non-ship activity. The C1C2 AIS data were quality assured including the removal of duplicate messages, signals from pleasure craft, and signals that were not from CMV vessels (e.g., buoys, helicopters, and vessels that are not self-propelled). Following this, there were 422 million records remaining.

The emissions were calculated for each time interval between consecutive AIS messages for each vessel and allocated to the location of the message following to the interval. Emissions were calculated according to **Equation 2-1**.

$$Emissions_{interval} = Time\ (hr)_{interval} \times\ Power(kW) \times EF(g/kWh) \times LLAF \qquad \textbf{Equation 2-1}$$

Power is calculated for the propulsive (main), auxiliary, and auxiliary boiler engines for each interval and emission factor (EF) reflects the assigned emission factors for each engine, as described below. LLAF represents the low load adjustment factor, a unitless factor which reflects increasing propulsive emissions during low load operations. Time indicates the activity duration time between consecutive intervals.

Next, vessels were identified in order determine their vessel type, and thus their vessel group, power rating, and engine tier information which are required for the emissions calculations. See the 2017 NEI documentation for more details on this process. Following the identification, 108 different vessel types were matched to the C1C2 vessels. Vessel attribute data was not available for all these vessel types, so the vessel types were aggregated into 13 different vessel groups for which surrogate data were available as shown in Table 2-19. 11,302 vessels were directly identified by their ship and cargo number. The remaining group of miscellaneous ships represent 13 percent of the AIS vessels (excluding recreational vessels) for which a specific vessel type could not be assigned.

Table 2-19. Vessel groups in the cmv_c1c2 sector

Vessel Group	NEI Area Ship Count
Bulk Carrier	**37**
Commercial Fishing	**1,147**
Container Ship	**7**
Ferry Excursion	**441**
General Cargo	**1,498**
Government	**1,338**
Miscellaneous	**1,475**
Offshore support	**1,149**
Reefer	**13**
Ro	**26**
Tanker	**100**
Tug	**3,994**
Work Boat	**77**
Total in Inventory:	**11,302**

As shown in **Equation 2-1**, power is an important component of the emissions computation. Vessel-specific installed propulsive power ratings and service speeds were pulled from Clarksons ship registry and adopted from the Global Fishing Watch (GFW) dataset when available. However, there is limited vessel specific attribute data for most of the C1C2 fleet. This necessitated the use of surrogate engine power and load factors, which were computed for each vessel group shown in Table 2-19. In addition to the power required by propulsive engines, power needs for auxiliary engines were also computed for each vessel group. Emissions from main and auxiliary engines are inventoried with different SCCs as shown in Table 2-18.

The final components of the emissions computation equation are the emission factors and the low load adjustment factor. The emission factors used in this inventory take into consideration the EPA's marine vessel fuel regulations as well as exhaust standards that are based on the year that the vessel was manufactured to determine the appropriate regulatory tier. Emission factors in g/kWhr by tier for NO_x, PM_{10}, $PM_{2.5}$, CO, CO_2, SO_2 and VOC were developed using Tables 3-7 through 3-10 in USEPA's (2008) Regulatory Impact Analysis on engines less than 30 liters per cylinder. To compile these emissions factors, population-weighted average emission factors were calculated per tier based on C1C2 population distributions grouped by engine displacement. Boiler emission factors were obtained from an earlier Swedish Environmental Protection Agency study (Swedish EPA, 2004). If the year of manufacture was unknown then it was assumed that the vessel was Tier 0, such that actual emissions may be less than those estimated in this inventory. Without more specific data, the magnitude of this emissions difference cannot be estimated.

Propulsive emissions from low-load operations were adjusted to account for elevated emission rates associated with activities outside the engines' optimal operating range. The emission factor adjustments were applied by load and pollutant, based on the data compiled for the Port Everglades 2015 Emission Inventory.[7] Hazardous air pollutants and ammonia were added to the inventory according to multiplicative factors applied either to VOC or $PM_{2.5}$.

For more information on the emission computations for 2017, see the supporting documentation for the 2017 NEI C1C2 CMV emissions. The emissions from the 2017 NEI were adjusted to represent 2016 in the cmv_c1c2 sector using factors derived from U.S. Army Corps of Engineers national vessel Entrance and Clearance data[8] by applying a factor of 0.98 to all pollutants (based on EIA fuel use data). For consistency, the same methods were used for California, Canadian, and other non-U.S. emissions. The 2017 emissions were mapped to 2016 dates so that the activity occurred on the same day of the week in the same sequential week of the year in both years. Emissions that occurred on a federal holiday in 2017 were mapped to the same holiday on the corresponding 2016 date. Individual vessels that released emissions within the same grid cell for over 400 hours were flagged as hoteling. The emissions from the hoteling vessels were scaled to the 400-hour cap.

2.4.2 Category 3 Commercial Marine Vessels (cmv_c3)

The 2016v3 CMV emissions are based on the emissions developed for the 2017 NEI and are the same as those used in the 2016v2 platform, except that for 2016v3 the spatial allocation to county boundaries was improved in response to comments. The cmv_c3 inventory are the same as those in the 2016v1 platform and were developed in conjunction with the CMV inventory for the 2017 NEI. This sector contains large engine CMV emissions. Category 3 (C3) marine diesel engines are those at or above 30 liters per cylinder, typically these are the largest engines rated at 3,000 to 100,000 hp. C3 engines are typically used for propulsion on ocean-going vessels including container ships, oil tankers, bulk carriers, and cruise ships. Emissions control technologies for C3 CMV sources are limited due to the nature of the residual

---

[7] USEPA. EPA and Port Everglades Partnership: Emission Inventories and Reduction Strategies. US Environmental Protection Agency, Office of Transportation and Air Quality, June 2018. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100UKV8.pdf.

[8] U.S. Army Corps of Engineers (USACE). Foreign Waterborne Transportation: Foreign Cargo Inbound and Outbound Vessel Entrances and Clearances. US Army Corps of Engineers, 2018.

fuel used by these vessels.[9] The cmv_c3 sector contains sources that traverse state and federal waters; along with sources in waters not covered by the NEI in surrounding areas of Canada, Mexico, and international waters.

The cmv_c3 sources that operate outside of state waters but within the federal Emissions Control Area (ECA) are encoded with a FIPS state code of 85, with the "county code" digits representing broad regions such as the Atlantic, Gulf of Mexico, and Pacific. The ECA areas include parts of the Gulf of Mexico, and parts of the Atlantic and Pacific coasts. CMV C3 sources around Puerto Rico, Hawaii and Alaska, which are outside the ECA areas, are included in the 2016v1 inventory but are in separate files from the emissions around the continental United States (CONUS). The cmv_c3 sources in the 2016v2 inventory are categorized as operating either in-port or underway and are encoded using the SCCs listed in Table 2-20. and distinguish between diesel and residual fuel, in port areas versus underway, and main and auxiliary engines. In addition to C3 sources in state and federal waters, the cmv_c3 sector includes emissions in waters not covered by the NEI (FIPS = 98) and taken from the "ECA-IMO-based" C3 CMV inventory.[10] The ECA-IMO inventory is also used for allocating the FIPS-level emissions to geographic locations for regions within the domain not covered by the AIS selection boxes as described in the next section.

Table 2-20. SCCs for cmv_c3 sector

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2280002103	C3	Diesel	Port	Main
2280002104	C3	Diesel	Port	Auxiliary
2280002203	C3	Diesel	Underway	Main
2280002204	C3	Diesel	Underway	Auxiliary
2280003103	C3	Residual	Port	Main
2280003104	C3	Residual	Port	Auxiliary
2280003203	C3	Residual	Underway	Main
2280003204	C3	Residual	Underway	Auxiliary

Prior to creation of the 2017 NEI, the EPA received Automated Identification System (AIS) data from United States Coast Guard (USCG) to quantify all ship activity which occurred between January 1 and December 31, 2017. The International Maritime Organization's (IMO's) International Convention for the Safety of Life at Sea (SOLAS) requires AIS to be fitted aboard all international voyaging ships with gross tonnage of 300 or more, and all passenger ships regardless of size.[11] In addition, the USCG has mandated that all commercial marine vessels continuously transmit AIS signals while transiting U.S. navigable waters. As the vast majority of C3 vessels meet these requirements, any omitted from the inventory due to lack of AIS adoption are deemed to have a negligible impact on national C3 emissions estimates. The activity described by this inventory reflects ship operations within 200 nautical miles of the official U.S.

[9] https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-marine-vessels.
[10] https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf.
[11] International Maritime Organization (IMO) Resolution MSC.99(73) adopted December 12th. 2000 and entered into force July 1st, 2002; as amended by SOLAS Resolution CONF.5/32 adopted December 13th, 2002.

baseline. This boundary is roughly equivalent to the border of the U.S Exclusive Economic Zone and the North American ECA, although some non-ECA activity is captured as well (Figure 2-4).

The 2017 NEI data were computed based on the AIS data from the USCG for the year of 2017. The AIS data were coupled with ship registry data that contained engine parameters, vessel power parameters, and other factors such as tonnage and year of manufacture which helped to separate the C3 vessels from the C1C2 vessels. Where specific ship parameters were not available, they were gap-filled. The types of vessels that remain in the C3 data set include bulk carrier, chemical tanker, liquified gas tanker, oil tanker, other tanker, container ship, cruise, ferry, general cargo, fishing, refrigerated vessel, roll-on/roll-off, tug, and yacht.

Prior to use, the AIS data were reviewed - data deemed to be erroneous were removed, and data found to be at intervals greater than 5 minutes were interpolated to ensure that each ship had data every five minutes. The five-minute average data provide a reasonably refined assessment of a vessel's movement. For example, using a five-minute average, a vessel traveling at 25 knots would be captured every two nautical miles that the vessel travels. For slower moving vessels, the distance between transmissions would be less.

The emissions were calculated for each C3 vessel in the dataset for each 5-minute time range and allocated to the location of the message following to the interval. Emissions were calculated according to **Equation 2-2**.

$$Emissions_{interval} = Time\ (hr)_{interval} \times Power(kW) \times EF(g/kWh) \times LLAF \qquad \textbf{Equation 2-2}$$

Power is calculated for the propulsive (main), auxiliary, and auxiliary boiler engines for each interval and emission factor (EF) reflects the assigned emission factors for each engine, as described below. LLAF represents the low load adjustment factor, a unitless factor which reflects increasing propulsive emissions during low load operations. Time indicates the activity duration time between consecutive intervals.

Emissions were computed according to a computed power need (kW) multiplied by the time (hr) and by an engine-specific emission factor (g/kWh) and finally by a low load adjustment factor that reflects increasing propulsive emissions during low load operations.

The resulting emissions were available at 5-minute intervals. Code was developed to aggregate these emissions to modeling grid cells and up to hourly levels so that the emissions data could be input to SMOKE for emissions modeling with SMOKE. Within SMOKE, the data were speciated into the pollutants needed by the air quality model,[12] but since the data were already in the form of point sources at the center of each grid cell, and they were already hourly, no other processing was needed within SMOKE. SMOKE requires an annual inventory file to go along with the hourly data, so those files were also generated for each year.

[12] Ammonia (NH_3) was also added by SMOKE in the speciation step.

On January 1st, 2015, the ECA initiated a fuel sulfur standard which regulated large marine vessels to use fuel with 1,000 ppm sulfur or less. These standards are reflected in the cmv_c3 inventories.

There were some areas needed for modeling that the AIS request boxes did not cover (see Figure 2-4). These include a portion of the St. Lawrence Seaway transit to the Great Lakes, a small portion of the Pacific Ocean far offshore of Washington State, portions of the southern Pacific Ocean around off the coast of Mexico, and the southern portion of the Gulf of Mexico that is within the 36-km domain used for air quality modeling. In addition, a determination had to be made regarding whether to use the existing Canadian CMV inventory or the more detailed AIS-based inventory. The AIS-based inventory was used in the areas for which data were available, and the areas not covered were gap-filled with inventory data from the 2016beta platform, which included data from ECCC and the 2011 ECA-IMO C3 inventory.

For the gap-filled areas not covered by AIS selected data areas or the ECCC inventory, the 2016 nonpoint C3 inventory provided by ECCC was converted to a point inventory to support plume rise calculations for C3 vessels. The nonpoint emissions were allocated to point sources using a multi-step allocation process because not all of the inventory components had a complete set of county-SCC combinations. In the first step, the county-SCC sources from the nonpoint file were matched to the county-SCC points in the 2011 ECA-IMO C3 inventory. The ECA-IMO inventory contains multiple point locations for each county-SCC. The nonpoint emissions were allocated to those points using the $PM_{2.5}$ emissions at each point as a weighting factor.

For cmv_c3 underway emissions without a matching FIPS in the ECA-IMO inventory were allocated using the 12 km 2014 offshore shipping activity spatial surrogate (surrogate code 806). Each county with underway emissions in the area inventory was allocated to the centroids of the cells associated with the respective county in the surrogate. The emissions were allocated using the weighting factors in the surrogate.

The resulting point emissions centered on each grid cell were converted to an annual point 2010 flat file format (FF10). A set of standard stack parameters were assigned to each release point in the cmv_c3 inventory. The assigned stack height was 65.62 ft, the stack diameter was 2.625 ft, the stack temperature was 539.6 °F, and the velocity was 82.02 ft/s. Emissions were computed for each grid cell needed for modeling.

Adjustment of the 2017 NEI CMV C3 to 2016

Because the NEI emissions data were for 2017, an analysis was performed of 2016 versus 2017 entrance and clearance data (ERG, 2019c). Annual, monthly, and daily level data were reviewed. Annual ratios of entrance and clearance activity were developed for each ship type as shown in Table 2-21. For vessel types with low populations (C3 Yacht, tug, barge, and fishing vessels), an annual ratio of 0.98 was applied. The 2017 emissions were mapped to 2016 dates so that the activity occurred on the same day of the week in the same sequential week of the year in both years. Emissions that occurred on a federal holiday in 2017 were mapped to the same holiday on the corresponding 2016 date. Individual vessels that released emissions within the same grid cell for over 400 hours were flagged as hoteling. The emissions from the hoteling vessels were scaled to the 400-hour cap.

Table 2-21. 2017 to 2016 projection factors for C3 CMV

Ship Type	Annual Ratio[a]
Barge	1.551
Bulk Carrier	1.067
Chemical Tanker	1.031
Container Ship	1.0345
Cruise	1.008
Ferry Ro Pax	1.429
General Cargo	0.888
Liquified Gas Tanker	1.192
Miscellaneous Fishing	0.932
Miscellaneous Other	1.015
Offshore	0.860
Oil Tanker	1.101
Other Tanker	1.037
Reefer	0.868
Ro Ro	1.007
Service Tug	1.074

[a] The above ratios were applied to the 2017 emission values to estimate 2016 values; thus ratios > 1 mean that emissions were larger in 2016

The cmv_c3 projection factors were pollutant-specific and region-specific. Most states are mapped to a single region with a few exceptions. Pennsylvania and New York were split between the East Coast and Great Lakes, Florida was split between the Gulf Coast and East Coast, and Alaska was split between Alaska East and Alaska West. The non-federal factors listed in this table were applied to sources outside of U.S. federal waters (FIPS 98). Volatile Organic Compound (VOC) Hazardous Air Pollutant (HAP) emissions were projected using the VOC factors. NH3 emissions were computed by multiplying PM2.5 by 0.019247.

2.4.3 Railway Locomotives (rail)

There were no changes to the rail sector emissions inventories between 2016v1 and 2016v2 aside from updating emissions for seven rail yards in Georgia. There were no changes between the 2016v2 and 2016v3 rail emissions. The rail sector includes all locomotives in the NEI nonpoint data category. The rail sector SCCs are shown in Table 2-22. This sector excludes railway maintenance activities. Railway maintenance emissions are included in the nonroad sector. The point source yard locomotives are included in the ptnonipm sector. In 2014NEIv2, rail yard locomotive emissions were present in both the nonpoint (rail sector) and point (ptnonipm sector) inventories. For the 2016v1 and 2016v2 platforms, rail yard locomotive emissions are only in the ptnonipm sector of the point inventory. Therefore, SCC 2285002010 is not present in the rail sector, except in three California counties because the California Air

Resources Board (CARB) submitted rail emissions, including rail yards, for 2016v1 platform. In three counties, CARB's rail yard emissions could not be mapped to point source rail yards, and so those counties' emissions were included in the rail sector.

Table 2-22. 2016v1 SCCs for the Rail Sector

SCC	Sector	Description: Mobile Sources prefix for all
2285002006	rail	Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations
2285002007	rail	Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations
2285002008	rail	Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak)
2285002009	rail	Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines
2285002010	rail	Railroad Equipment; Diesel; Yard Locomotives (nonpoint)
28500201	rail	Railroad Equipment; Diesel; Yard Locomotives (point)

Class I Line-haul Methodology

In 2008 air quality planners in the eastern US formed the Eastern Technical Advisory Committee (ERTAC) for solving persistent emissions inventory issues. This work is the fourth inventory created by the ERTAC rail group. For the 2016 inventory, the Class I railroads granted ERTAC Rail permission to use the confidential link-level line-haul activity GIS data layer maintained by the Federal Railroad Administration (FRA). In addition, the Association of American Railroads (AAR) provided national emission tier fleet mix information. This allowed ERTAC Rail to calculate weighted emission factors for each pollutant based on the percentage of the Class I line-haul locomotives in each USEPA Tier level category. These two datasets, along with 2016 Class I line-haul fuel use data reported to the Surface Transportation Board (Table 2-23), were used to create a link-level Class I emissions inventory, based on a methodology recommended by Sierra Research. Rail Fuel Consumption Index (RFCI) is a measure of fuel use per ton mile of freight. This link-level inventory is nationwide in extent, but it can be aggregated at either the state or county level.

Table 2-23. Class I Railroad Reported Locomotive Fuel Use Statistics for 2016

Class I Railroads	2016 R-1 Reported Locomotive Fuel Use (gal/year)		RFCI (ton-miles/gal)	Adjusted RFCI (ton-miles/gal)
	Line-Haul*	Switcher		
BNSF	1,243,366,255	40,279,454	972	904
Canadian National	102,019,995	6,570,898	1,164	1,081
Canadian Pacific	56,163,697	1,311,135	1,123	1,445
CSX Transportation	404,147,932	39,364,896	1,072	1,044
Kansas City Southern	60,634,689	3,211,538	989	995
Norfolk Southern	437,110,632	28,595,955	920	906
Union Pacific	900,151,933	85,057,080	1,042	1,095
Totals:	**3,203,595,133**	**204,390,956**	**1,006**	**993**

* Includes work trains; Adjusted RFCI values calculated from FRA gross ton-mile data. RFCI total is ton-mile weighted mean.

Annual default emission factors for locomotives based on operating patterns ("duty cycles") and the estimated nationwide fleet mixes for both switcher and line-haul locomotives are available. However, Tier level fleet mixes vary significantly between the Class I and Class II/III railroads. As can be seen in Figure 2-5 and Figure 2-6, Class I railroad activity is highly regionalized in nature and is subject to variations in terrain across the country which can have a significant impact on fuel efficiency and overall fuel consumption.

Figure 2-5. 2016 US Railroad Traffic Density in Millions of Gross Tons per Route Mile (MGT)

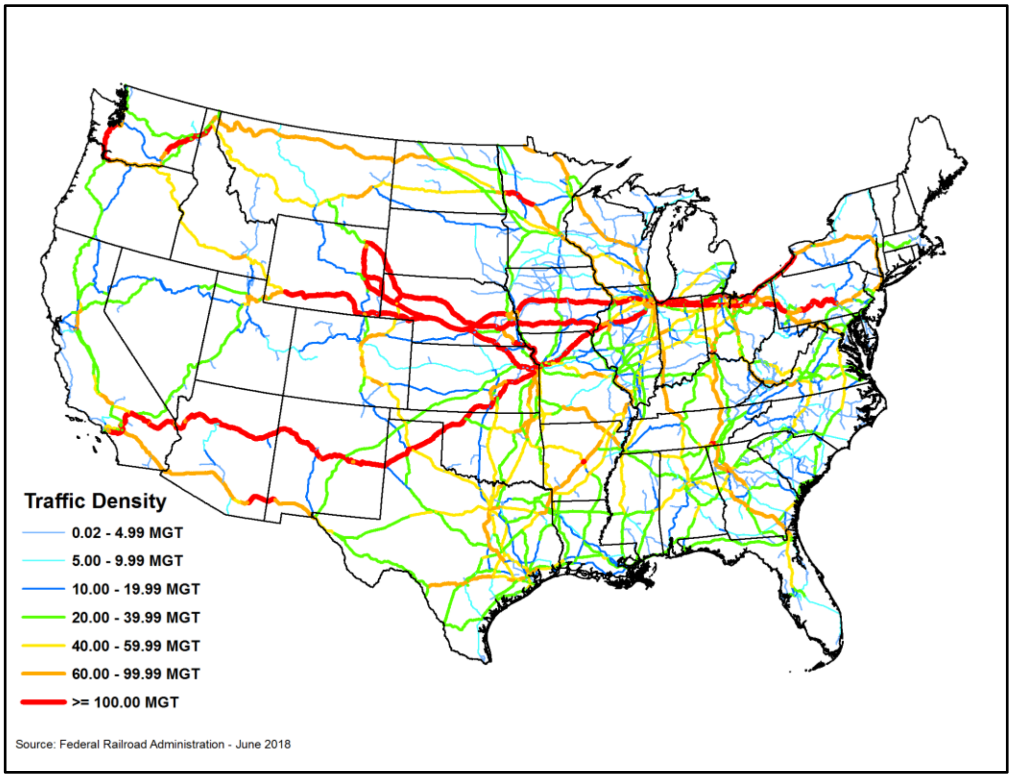
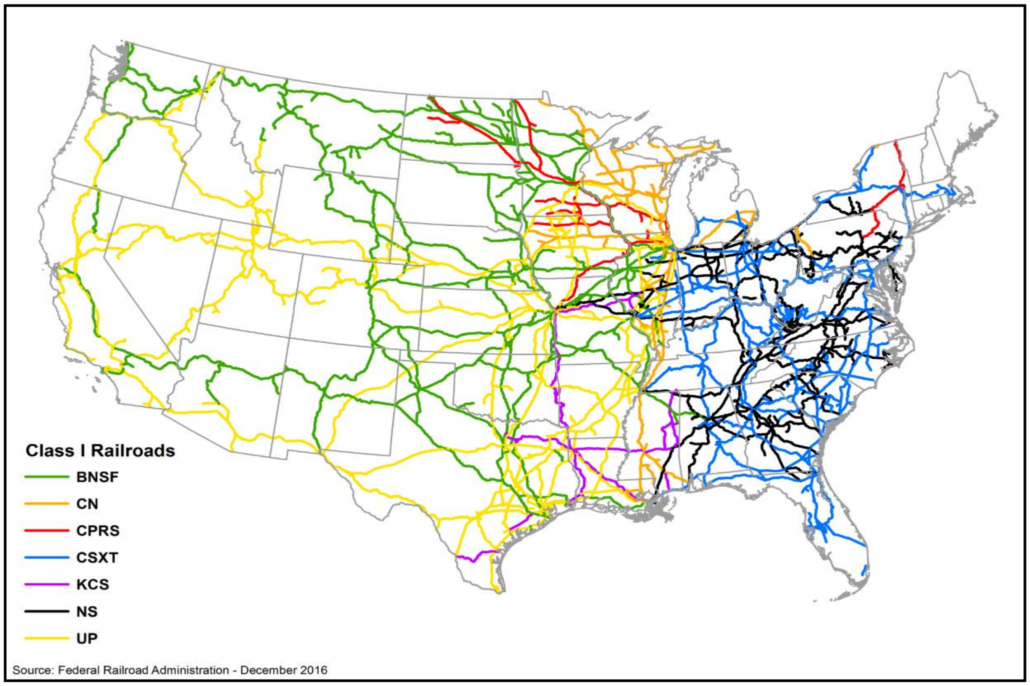


Figure 2-6. Class I Railroads in the United States[5]



For the 2016 inventory, the AAR provided a national line-haul Tier fleet mix profile representing the entire Class I locomotive fleet. A locomotive's Tier level determines its allowable emission rates based on the year when it was built and/or re-manufactured. The national fleet mix data was then used to calculate weighted average in-use emissions factors for the line-haul locomotives operated by the Class I railroads as shown in Table 2-24.

Table 2-24. 2016 Line-haul Locomotive Emission Factors by Tier, AAR Fleet Mix (grams/gal)

Tier Level	AAR Fleet Mix Ratio	PM_{10}	HC	NO_x	CO
Uncontrolled (pre-1973)	0.047494	6.656	9.984	270.4	26.624
Tier 0 (1973-2001)	0.188077	6.656	9.984	178.88	26.624
Tier 0+ (Tier 0 rebuilds)	0.141662	4.16	6.24	149.76	26.624
Tier 1 (2002-2004)	0.029376	6.656	9.776	139.36	26.624
Tier 1+ (Tier 1 rebuilds)	0.223147	4.16	6.032	139.36	26.624
Tier 2 (2005-2011)	0.124536	3.744	5.408	102.96	26.624
Tier 2+ (Tier 2 rebuilds)	0.093607	1.664	2.704	102.96	26.624
Tier 3 (2012-2014)	0.123113	1.664	2.704	102.96	26.624
Tier 4 (2015 and later)	0.028988	0.312	0.832	20.8	26.624
2016 Weighted EF's	**1.000000**	**4.117**	**6.153**	**138.631**	**26.624**

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009.

Weighted Emission Factors (EF) per pollutant for each gallon of fuel used (grams/gal or lbs/gal) were calculated for the US Class I locomotive fleet based on the percentage of line-haul locomotives certified at each regulated Tier level (Equation 2-3).

$$EF_i = \sum_{T=1}^{10} (EF_{iT} * f_T) \quad \text{Equation 2-3}$$

where:

EF_i = Weighted Emission Factor for pollutant *i* for Class I locomotive fleet (g/gal).
EF_{iT} = Emission Factor for pollutant *i* for locomotives in Tier T (g/gal).
f_T = Percentage of the Class I locomotive fleet in Tier T expressed as a ratio.

While actual engine emissions will vary within Tier level categories, the approach described above likely provides reasonable emission estimates, as locomotive diesel engines are certified to meet the emission standards for each Tier. It should be noted that actual emission rates may increase over time due to engine wear and degradation of the emissions control systems. In addition, locomotives may be operated in a manner that differs significantly from the conditions used to derive line-haul duty-cycle estimates.

Emission factors for other pollutants are not Tier-specific because these pollutants are not directly regulated by USEPA's locomotive emission standards. $PM_{2.5}$ was assumed to be 97% of PM_{10}, the ratio of volatile organic carbon (VOC) to (hydrocarbon) HC was assumed to be 1.053, and the emission factors used for sulfur dioxide (SO_2) and ammonia (NH_3) were 0.0939 g/gal and 83.3 mg/gal, respectively. The 2016 SO_2 emission factor is based on the nationwide adoption of 15 ppm ultra-low sulfur diesel (ULSD) fuel by the rail industry.

The remaining steps to compute the Class I rail emissions involved calculating Class I railroad-specific rail fuel consumption index values and calculating emissions per link. The final link-level emissions for each pollutant were then aggregated by state/county FIPS code and then converted into an FF10 file format for input to SMOKE. More detail on these steps is described in the specification sheet for the 2016v1 rail sector emissions.

Rail yard Methodology

Rail yard emissions were computed based on fuel use and/or yard switcher locomotive counts for the class I rail companies for all of the rail yards on their systems. Three railroads provided complete rail yard datasets: BNSF, UP, and KCS. CSX provided switcher counts for its 14 largest rail yards. This reported activity data was matched to existing yard locations and data stored in USEPA's Emissions Inventory System (EIS) database. All existing EIS yards that had activity data assigned for prior years, but no reported activity data for 2016 were zeroed out. New yard data records were generated for reported locations that were not found in EIS. Special care was made to ensure that the new yards added to EIS did not duplicate existing data records. Data for non-Class I yards was carried forward from the 2014 NEI. Georgia provided updates on seven rail yards that were incorporated into 2016v2.

Since the railroads only supplied switcher counts, average fuel use per switcher values was calculated for each railroad. This was done by dividing each company's 2016 R-1 yard fuel use total by the number of switchers reported for each railroad. These values were then used to allocate fuel use to each yard based on the number of switchers reported for that location. Table 2-25 summarizes the 2016 yard fuel use and switcher data for each Class I railroad. The emission factors used for rail yard switcher engines are shown in Table 2-26.

Table 2-25. Surface Transportation Board R-1 Fuel Use Data – 2016

Railroad	2016 R-1 Yard Fuel Use (gal)	ERTAC calculated Fuel Use (gal)	Identified Switchers	ERTAC per Switcher Fuel Use (gal)
BNSF	40,279,454	40,740,317	442	92,173
CSXT	39,364,896	43,054,795	455	94,626
CN	6,570,898	6,570,898	103	63,795
KCS	3,211,538	3,211,538	176	18,247
NS	28,595,955	28,658,528	458	62,573
CPRS	1,311,135	1,311,135	70	18,731
UP	85,057,080	85,057,080	1286	66,141
All Class I's	**204,390,956**	**208,604,291**	**2,990**	**69,767**

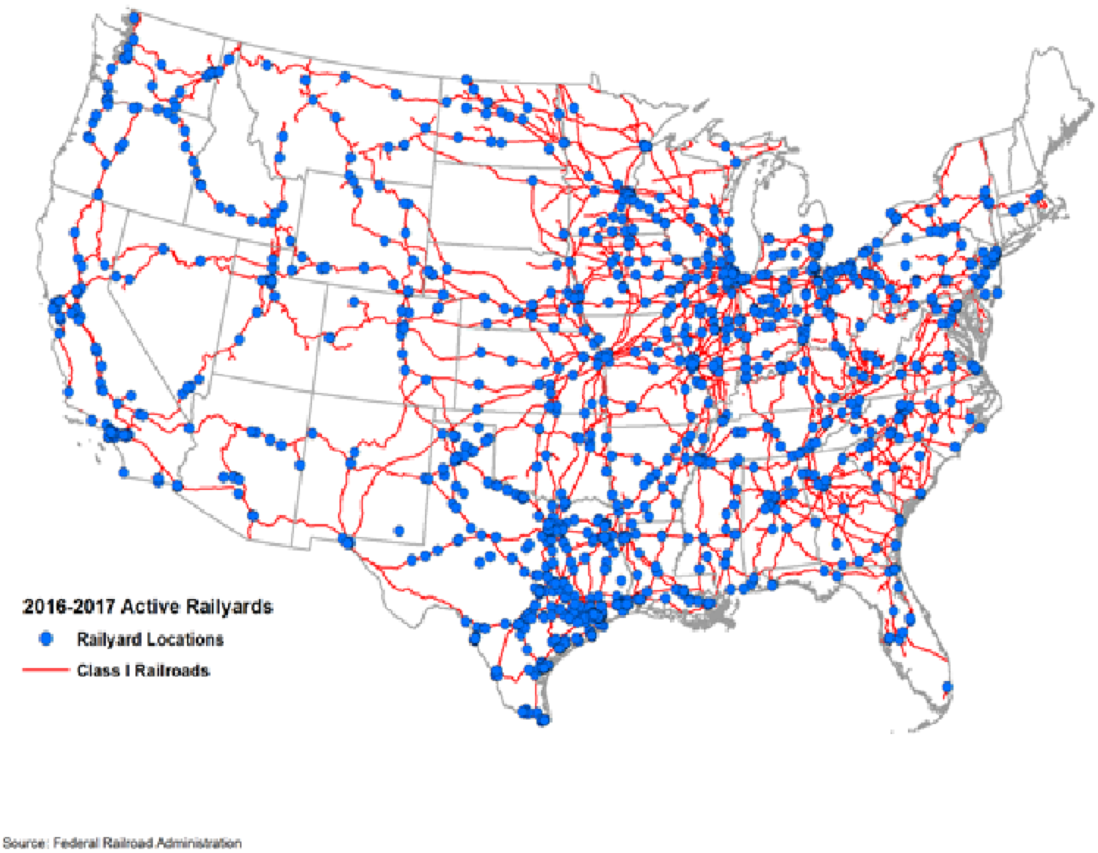
Table 2-26. 2016 Yard Switcher Emission Factors by Tier, AAR Fleet Mix (grams/gal)[4]

Tier Level	AAR Fleet Mix Ratio	PM_{10}	HC	NO_x	CO
Uncontrolled (pre-1973)	0.2601	6.688	15.352	264.48	27.816
Tier 0 (1973-2001)	0.2361	6.688	15.352	191.52	27.816
Tier 0+ (Tier 0 rebuilds)	0.2599	3.496	8.664	161.12	27.816
Tier 1 (2002-2004)	0.0000	6.536	15.352	150.48	27.816
Tier 1+ (Tier 1 rebuilds)	0.0476	3.496	8.664	150.48	27.816
Tier 2 (2005-2011)	0.0233	2.888	7.752	110.96	27.816
Tier 2+ (Tier 2 rebuilds)	0.0464	1.672	3.952	110.96	27.816
Tier 3 (2012-2014)	0.1018	1.216	3.952	68.4	27.816
Tier 4 (2015 and later)	0.0247	0.228	1.216	15.2	27.816
2016 Weighted EF's	**0.9999**	**4.668**	**11.078**	**178.1195**	**27.813**

Based on values in EPA Technical Highlights: Emission Factors for Locomotives, EPA Office of Transportation and Air Quality, EPA-420-F-09-025, April 2009. AAR fleet mix ratios did not add up to 1.0000, which caused a small error for the CO weighted emission factor as shown above.

In addition to the Class I rail yards, Emission estimates were calculated for four large Class III railroad hump yards which are among the largest classification facilities in the United States. These four yards are located in Chicago (Belt Railway of Chicago-Clearing and Indiana Harbor Belt-Blue Island) and Metro-East St. Louis (Alton & Southern-Gateway and Terminal Railroad Association of St. Louis-Madison). Figure 2-7 shows the spatial distribution of active yards in the 2016v1 and 2017 NEI inventories.

Figure 2-7. 2016-2017 Active Rail Yard Locations in the United States

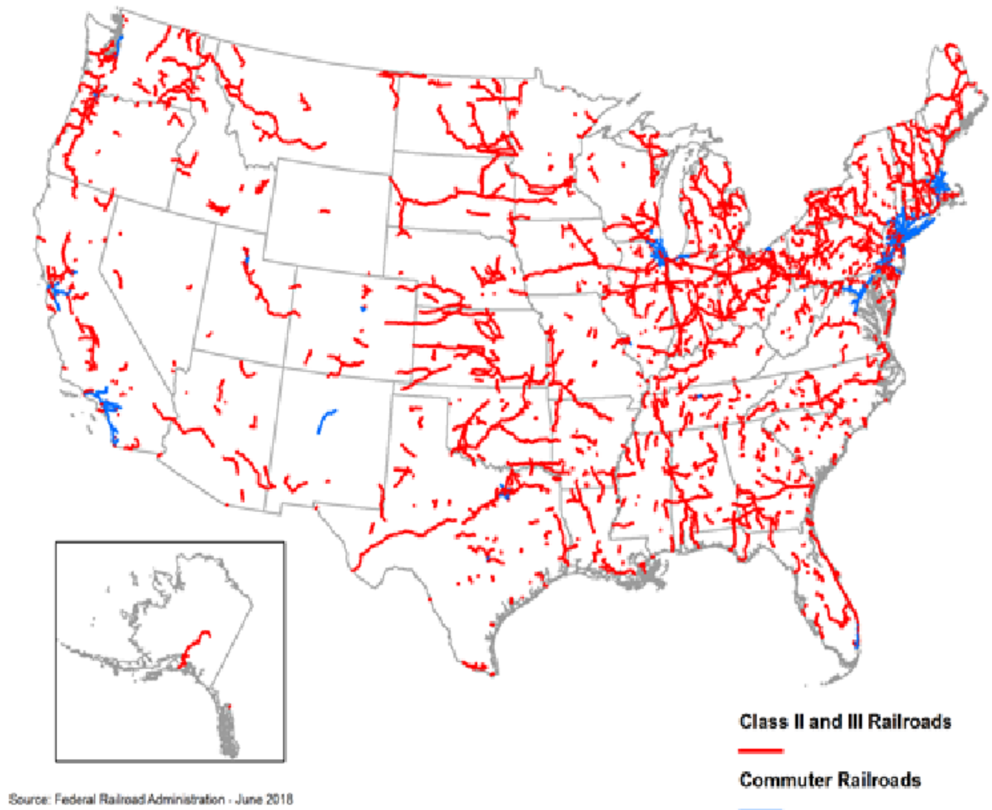


Class II and III Methodology

There are approximately 560 Class II and III Railroads operating in the United States, most of which are members of the American Short Line and Regional Railroad Association (ASLRRA). While there is a lot of information about individual Class II and III railroads available online, a significant amount of effort would be required to convert this data into a usable format for the creation of emission inventories. In addition, the Class II and III rail sector has been in a constant state of flux ever since the railroad industry was deregulated under the Staggers Act in 1980. Some states have conducted independent surveys of their Class II and III railroads and produced emission estimates, but no national level emissions inventory existed for this sector of the railroad industry prior to ERTAC Rail's work for the 2008 NEI.

Class II and III railroad activities account for nearly 4 percent of the total locomotive fuel use in the combined ERTAC Rail emission inventories and for approximately 35 percent of the industry's national freight rail track mileage. These railroads are widely dispersed across the country and often utilize older, higher emitting locomotives than their Class I counterparts. Class II and III railroads provide transportation services to a wide range of industries. Individual railroads in this sector range from small switching operations serving a single industrial plant to large regional railroads that operate hundreds of miles of track. Figure 2-8 shows the distribution of Class II and III railroads and commuter railroads across the country. This inventory will be useful for regional and local modeling, helps identify where Class II and III railroads may need to be better characterized, and provides a strong foundation for the eventual development of a more accurate nationwide short line and regional railroad emissions inventory. The data sources, calculations, and assumptions used to develop the Class II and III inventory are described in the 2016v1 rail specification sheet.

Figure 2-8. Class II and III Railroads in the United States[5]



Commuter Rail Methodology

Commuter rail emissions were calculated in the same way as the Class II and III railroads. The primary difference is that the fuel use estimates were based on data collected by the Federal Transit Administration (FTA) for the National Transit Database. 2016 fuel use was then estimated for each of the commuter railroads shown in Table 2-27 by multiplying the fuel and lube cost total by 0.95, then dividing the result by Metra's average diesel fuel cost of $1.93/gallon. These fuel use estimates were replaced with reported fuel use statistics for MARC (Maryland), MBTA (Massachusetts), Metra (Illinois), and NJT (New Jersey). The commuter railroads were separated from the Class II and III railroads so that the appropriate SCC codes could be entered into the emissions calculation sheet.

Table 2-27. Expenditures and fuel use for commuter rail

FRA Code	System	Cities Served	Propulsion Type	DOT Fuel & Lube Costs	Reported/Estimated Fuel Use
ACEX	Altamont Corridor Express	San Jose / Stockton	Diesel	$889,828	437,998.24
CMRX	Capital MetroRail	Austin	Diesel	No data	n/a
DART	A-Train	Denton	Diesel	$0	0.00
DRTD	Denver RTD: A&B Lines	Denver	Electric	$0	0.00

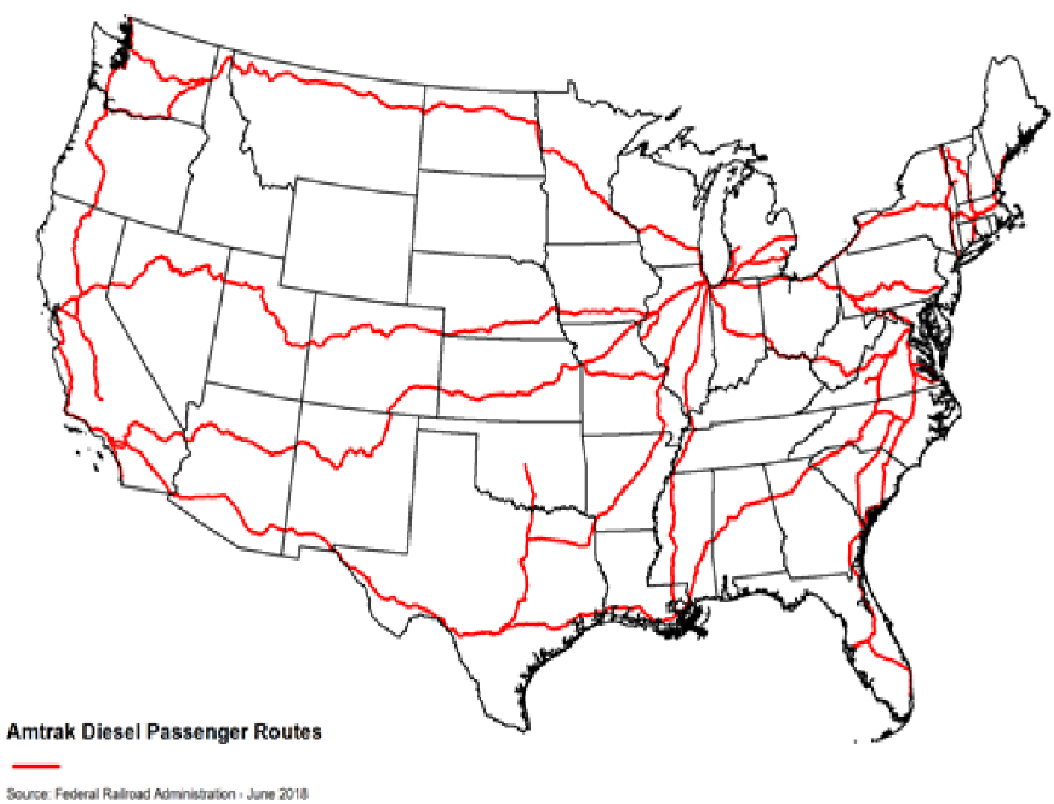
FRA Code	System	Cities Served	Propulsion Type	DOT Fuel & Lube Costs	Reported/Estimated Fuel Use
JPBX	Caltrain	San Francisco / San Jose	Diesel	$7,002,612	3,446,881.55
LI	MTA Long Island Rail Road	New York	Electric and Diesel	$13,072,158	6,434,481.92
MARC	MARC Train	Baltimore / Washington, D.C.	Diesel and Electric	$4,648,060	***4,235,297.57***
MBTA	MBTA Commuter Rail	Boston / Worcester / Providence	Diesel	$37,653,001	***12,142,826.00***
MNCW	MTA Metro-North Railroad	New York / Yonkers / Stamford	Electric and Diesel	$13,714,839	6,750,827.49
NICD	NICTD South Shore Line	Chicago / South Bend	Electric	$181,264	0.00
NIRC	Metra	Chicago	Diesel and Electric	$52,460,705	***25,757,673.57***
NJT	New Jersey Transit	New York / Newark / Trenton / Philadelphia	Electric and Diesel	$38,400,031	***16,991,164.00***
NMRX	New Mexico Rail Runner	Albuquerque / Santa Fe	Diesel	$1,597,302	786,236.74
CFCR	SunRail	Orlando	Diesel	$856,202	421,446.58
MNRX	Northstar Line	Minneapolis	Diesel	$708,855	348,918.26
Not Coded	SMART	San Rafael-Santa Rosa (Opened 2017)	Diesel	n/a	0.00
NRTX	Music City Star	Nashville	Diesel	$456,099	224,504.69
SCAX	Metrolink	Los Angeles / San Bernardino	Diesel	$19,245,255	9,473,052.98
SDNR	NCTD Coaster	San Diego / Oceanside	Diesel	$1,489,990	733,414.77
SDRX	Sounder Commuter Rail	Seattle / Tacoma	Diesel	$1,868,019	919,491.22
SEPA	SEPTA Regional Rail	Philadelphia	Electric	$483,965	0.00
SLE	Shore Line East	New Haven	Diesel	No data	n/a
TCCX	Tri-Rail	Miami / Fort Lauderdale / West Palm Beach	Diesel	$5,166,685	2,543,186.92
TREX	Trinity Railway Express	Dallas / Fort Worth	Diesel	No data	n/a
UTF	UTA FrontRunner	Salt Lake City / Provo	Diesel	$4,044,265	1,990,700.39
VREX	Virginia Railway Express	Washington, D.C.	Diesel	$3,125,912	1,538,661.35
WSTX	Westside Express Service	Beaverton	Diesel	No data	n/a

*Reported fuel use values were used for MARC, MBTA, Metra, and New Jersey Transit.

Intercity Passenger Methodology (Amtrak)

2016 marked the first time that a nationwide intercity passenger rail emissions inventory was created for Amtrak. The calculation methodology mimics that used for the Class II and III and commuter railroads with a few modifications. Since link-level activity data for Amtrak was unavailable, the default assumption was made to evenly distribute Amtrak's 2016 reported fuel use across all of it diesel-powered route-miles shown in Figure 2-9. Participating states were instructed that they could alter the fuel use distribution within their jurisdictions by analyzing Amtrak's 2016 national timetable and calculating passenger train-miles for each affected route. Illinois and Connecticut chose to do this and were able to derive activity-based fuel use numbers for their states based on Amtrak's 2016 reported average fuel use of 2.2 gallons per passenger train-mile. In addition, Connecticut provided supplemental data for selected counties in Massachusetts, New Hampshire, and Vermont. Amtrak also submitted company-specific fleet mix information and company-specific weighted emission factors were derived. Amtrak's emission rates were 25% lower than the default Class II and III and commuter railroad emission rate. Details on the computation of the Amtrak emissions are available in the rail specification sheet.

Figure 2-9. Amtrak Routes with Diesel-powered Passenger Trains



Other Data Sources

The California Air Resources Board (CARB) provided rail inventories for inclusion in the 2016v1 platform. CARB's rail inventories were used in California, in place of the national dataset described above. For rail yards, the national point source rail yard dataset was used to allocate CARB-submitted rail yard emissions to point sources where possible. That is, for each California county with at least one rail yard in the national dataset, the emissions in the national rail yard dataset were adjusted so that county total rail yard emissions matched the CARB dataset. In other words, 2016v1 and 2016v2 platforms include county total rail yard emissions from CARB, but the locations of rail yards are based on the national methodology. There are three counties with CARB-submitted rail yard emissions, but no rail yard locations in the national dataset; for those counties, the rail yard emissions were included in the rail sector using SCC 2285002010.

North Carolina separately provided passenger train (SCC 2285002008) emissions for use in the platform. We used NC's passenger train emissions instead of the corresponding emissions from the Lake Michigan Air Directors Consortium (LADCO) dataset.

None of these rail inventory sources included HAPs. For VOC speciation, the EPA preferred augmenting the inventory with HAPs and using those HAPs for integration, rather than running the sector as a no-integrate sector. So, Naphthalene, Benzene, Acetaldehyde, Formaldehyde, and Methanol (NBAFM) emissions were added to all rail inventories, including the California inventory, using the same augmentation factors as are used to augment HAPs in the NEI.

2.4.4 Nonroad Mobile Equipment (nonroad)

The mobile nonroad equipment sector includes all mobile source emissions that do not operate on roads, excluding commercial marine vehicles, railways, and aircraft. Types of nonroad equipment include recreational vehicles, pleasure craft, and construction, agricultural, mining, and lawn and garden equipment. Nonroad equipment emissions were computed by running the MOVES3,[13] which incorporates the NONROAD model. MOVES3 and its predecessor MOVES2014b incorporated updated nonroad engine population growth rates, nonroad Tier 4 engine emission rates, and sulfur levels of nonroad diesel fuels. MOVES3 provides a complete set of HAPs and incorporates updated nonroad emission factors for HAPs. MOVES3 was used for all states other than California and Texas, which developed their own emissions using their own tools. VOC and PM speciation profile assignments are determined by MOVES and applied by SMOKE. The fuels data in MOVES3 for nonroad vehicles is slightly updated from the MOVES2014b fuels for nonroad vehicles. 2016v2 and 2016v3 nonroad emissions are unchanged from 2016v1.

MOVES3 provides estimates of NONHAPTOG along with the speciation profile code for the NONHAPTOG emission source. This was accomplished by using NHTOG#### as the pollutant code in the Flat File 2010 (FF10) inventory file that can be read into SMOKE, where #### is a speciation profile code. One of the speciation profile codes is '95335a' (lowercase 'a'); the corresponding inventory pollutant is NONHAPTOG95335A (uppercase 'A') because SMOKE does not support inventory pollutant names with lowercase letters. Since speciation profiles are applied by SCC and pollutant, no changes to SMOKE were needed to use the inventory file with this profile information. This approach was not used for California or Texas, because the datasets in those states included VOC.

MOVES3, also provides estimates of PM2.5 by speciation profile code for the PM2.5 emission source, using PM25_#### as the pollutant code in the FF10 inventory file, where #### is a speciation profile code. To facilitate calculation of coarse particulate matter (PMC) within SMOKE, and to help create emissions summaries, an additional pollutant representing total $PM_{2.5}$ called PM25TOTAL was added to the inventory. As with VOC / TOG, this approach is not used for California or Texas.

[13] https://www.epa.gov/moves.

MOVES3 outputs emissions data in county-specific databases, and a post-processing script converts the data into FF10 format. Additional post-processing steps were performed as follows:

- County-specific FF10s were combined into a single FF10 file.
- Emissions were aggregated from the more detailed SCCs modeled in MOVES to the SCCs modeled in SMOKE. A list of the aggregated SMOKE SCCs is in Appendix A of the 2016v1 nonroad specification sheet.
- To reduce the size of the inventory, HAPs that are not needed for air quality modeling, such as dioxins and furans, were removed from the inventory.
- To reduce the size of the inventory further, all emissions for sources (identified by county/SCC) for which total CAP emissions are less than $1*10^{-10}$ were removed from the inventory. The MOVES model attributes a very tiny amount of emissions to sources that are actually zero, for example, snowmobile emissions in Florida. Removing these sources from the inventory reduces the total size of the inventory by about 7%.
- Gas and particulate components of HAPs that come out of MOVES separately, such as naphthalene, were combined.
- VOC was renamed VOC_INV so that SMOKE does not speciate both VOC and NONHAPTOG, which would result in a double count.
- PM25TOTAL, referenced above, was also created at this stage of the process.
- California and Texas emissions from MOVES were deleted and replaced with the CARB- and TCEQ-supplied emissions, respectively.

Emissions for airport ground support vehicles (SCCs ending in -8005), and oil field equipment (SCCs ending in -10010), were removed from the mobile nonroad inventory, to prevent a double count with the ptnonipm and np_oilgas sectors, respectively.

National Updates: Agricultural and Construction Equipment Allocation

The methodology for developing agricultural equipment allocation data for the 2016v1 platform was developed by the North Carolina Department of Environmental Quality (NCDEQ). EPA updated the construction equipment allocation data used in MOVES for the 2016v1 platform and the same updated data were used in the 2016v2 and 2016v3 platforms.

NCDEQ compiled regional and state-level agricultural sector fuel expenditure data for 2016 from the US Department of Agriculture, National Agricultural Statistics Service (NASS), August 2018 publication, "Farm Production Expenditures 2017 Summary."[14] This resource provides expenditures for each of 5 major regions that cover the Continental U.S., as well as state-level data for 15 major farm producing states. Because of the limited coverage of the NASS source relative to that in MOVES, it was necessary to identify a means for estimating the 2016 agricultural sector allocation data for the following States and Territories from a different source: Alaska, Hawaii, Puerto Rico, and U.S. Virgin Islands. The approach for these areas is described below.

[14] Accessed from http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1066, November 2018.

For the Continental U.S., NCDEQ first allocated the remainder of the regional fuel expenditures to states in each region for which state-level data are not reported. For this allocation, NCDEQ relied on 2012 fuel expenditure data from NASS' 2012 Census of Agriculture (note that 2017 data were not yet available at the time of this effort).[15] The next step to developing county-level allocation data for agricultural equipment was to multiply the state-level fuel expenditure estimates by county-level allocation ratios. These allocation ratios were computed from county-level fuel expenditure data from the NASS' 2012 Census of Agriculture. There were 17 counties for which fuel expenditure data were withheld in the Census of Agriculture. For these counties, NCDEQ allocated the fuel expenditures that were not accounted for in the applicable state via a surrogate indicator of fuel expenditures. For most states, the 2012 Census of Agriculture's total machinery asset value was the surrogate indicator used to perform the allocation. This indicator was found to have the strongest correlation to agricultural sector fuel expenditures based on analysis of 2012 state-level Census of Agriculture values for variables analyzed (correlation coefficient of 0.87).[16] Because the analyzed surrogate variables were not available for the two counties in New York without fuel expenditure data, farm sales data from the 2012 Census of Agriculture were used in the allocation procedure for these counties.

For Alaska and Hawaii, NCDEQ estimated 2016 state-level fuel production expenditures by first applying the national change in fuel expenditures between 2012 and 2016 from NASS' "Farm Production Expenditures" summary publications to 2012 state expenditure data from the 2012 Census of Agriculture. Next, NCDEQ applied an adjustment factor to account for the relationship between national 2012 fuel expenditures as reported by the Census of Agriculture and those reported in the Farm Production Expenditures Summary. Hawaii's state-level fuel expenditures were allocated to counties using the same approach as the states in the Continental U.S. (i.e., county-level fuel expenditure data from the NASS' 2012 Census of Agriculture). Alaska's fuel expenditures total was allocated to counties using a different approach because the 2012 Census of Agriculture reports fuel expenditures data for a different list of counties than the one included in MOVES. To ensure consistency with MOVES, NCDEQ allocated Alaska's fuel expenditures based on the current allocation data in MOVES, which reflect 2002 harvested acreage data from the Census of Agriculture.

Because NCDEQ did not identify any source of fuel expenditures data for Puerto Rico or the U.S. Virgin Islands, the county allocation percentages that are represented by the 2002 MOVES allocation data were used for these territories.[17]

For the construction sector, by default MOVES2014b used estimates of 2003 total dollar value of construction by county to allocate national construction equipment populations to the state and local levels.[18] However, the 2016 Nonroad Collaborative Work Group sought to update the surrogate data used to geographically allocate construction equipment with a more recent data source thought to be more reflective of emissions-generating construction equipment activity at the county level: acres disturbed by residential, non-residential, and road construction activity.

The nonpoint sector of the National Emissions Inventory (NEI) includes estimates of construction dust ($PM_{2.5}$), for which acreage disturbed by residential, non-residential, and road construction activity is a

---

[15] Accessed from https://www.nass.usda.gov/Publications/AgCensus/2012/, November 2018.
[16] Other variables analyzed were inventory of tractors and inventory of trucks.
[17] For reference, these allocations were 0.0639 percent for Puerto Rico and 0.0002 percent for the U.S. Virgin Islands.
[18] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1004LDX.pdf.

function.[19] The 2017 NEI Technical Support Document (EPA, 2021d) includes a description of the methods used to estimate acreage disturbed at the county level by residential, non-residential, and road construction activity, for the 50 states.

Acreage disturbed by residential, non-residential, and road construction were summed together to arrive at a single value of acreage disturbed by construction activities at the county level. County-level acreage disturbed were then summed together to arrive at acreage disturbed at the state level. State totals were then summed to arrive at a national total of acreage disturbed by construction activities.

Puerto Rico and the U.S. Virgin Islands are not included in the construction equipment geographic allocation update, so their relative share of the national population of construction equipment remains the same as MOVES2014b defaults.

For both the agricultural and construction equipment sectors, the *surrogatequant* and *surrogateyearID* fields in the model's *nrstatesurrogate* table, which allocates equipment from the state- to the county-level, were populated with the county-level surrogates described above (fuel expenditures in 2016 for agricultural equipment; acreage disturbed by construction activity in 2014 for construction equipment). In addition, the *nrbaseyearequippopulation* table, which apportions the model's national equipment populations to the state level, was adjusted so that each state's share of the MOVES base-year national populations of agricultural and construction equipment is proportional to each state's share of national acreage disturbed by construction activity (construction equipment) and agricultural fuel expenditures (agricultural equipment). Additionally, the model's *nrsurrogate* table, which defines the surrogate data used in the *nrstatesurrogate* table, was updated to reflect the 2016v1 changes to the agricultural and construction equipment sectors.

Updated *nrsurrogate*, *nrstatesurrogate*, and *nrbaseyearequippopulation* tables, along with instructions for utilizing these tables in MOVES runs, are available for download from EPA's ftp site at https://gaftp.epa.gov/air/emismod/2016/v1/reports/nonroad/.

State-Supplied Nonroad Data

As shown Table 2-28., several state and local agencies provided nonroad inputs for use in the 2016v1 platform that were carried forward into the 2016v2 and 2016v3 platforms. Additionally, per the table footnotes, EPA reviewed data submitted by state and local agencies for the 2014 and 2017 National Emissions Inventories and utilized that information where appropriate (data specific to calendar years 2014 and 2017 were not used in 2016v1). The *nrfuelsupply* table from MOVES3 was used in 2016v2 and 2016v3 and is therefore not shown in this table.

[19] https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data.

Table 2-28. **Submitted nonroad input tables by agency**

stateid	State or County(ies) in the Agency	**nrbaseyearequippopulation** (source populations)	**nrdayallocation** (allocation to day type)	**nrgrowthindex** (population growth)	**nrhourallocation** (allocation to diurnal pattern)	**nrmonthallocation** (seasonal allocation)	**nrsourceusetype** (yearly activity)	**nrstatesurrogate** (allocations to counties)	**countyyear** (Stage II information)	**nrequipmenttype** (surrogate selection)	**nrsurrogate** (surrogate identification)
4	ARIZONA - Maricopa Co.	A					D	D	D	D	D
9	CONNECTIC	A									
13	GEORGIA							D			
16	IDAHO		C								
17	ILLINOIS					E					
18	INDIANA		C			E					
19	IOWA		C			E					
26	MICHIGAN		C			E					
27	MINNESOTA		C			E					
29	MISSOURI					E					
36	NEW YORK	D	D	D	D	D	D	D			
39	OHIO		C			E					
49	UTAH	B	D	D	D			F			
53	WASHINGT							D		D	D
55	WISCONSIN					E					

[A] Submitted data with modification: updated the year ID to 2016.
[B] Submitted data with modification: deleted records that were not snowmobile source types 1002-1010.
[C] NEI 2014v2 data used for 2016v1 platform.
[D] Submitted data.
[E] Spreadsheet "ladco_nei2017_nrmonthallocation.xlsx."
[F] Submitted data with modification: deleted records that were not the snowmobile surrogate ID 14.

Emissions Inside California and Texas

California nonroad emissions were provided by CARB for the years 2016, 2023, 2028, and 2035.

All California nonroad inventories are annual, with monthly temporalization applied in SMOKE. Emissions for oil field equipment (SCCs ending in -10010) were removed from the California inventory in order to prevent a double count with the np_oilgas sector. VOC and $PM_{2.5}$ emissions were allocated to speciation profiles, and VOC HAPs were created, using MOVES data in California. For example, ratios of VOC ($PM_{2.5}$) by speciation profile to total VOC ($PM_{2.5}$), and ratios of VOC HAPs to total VOC, were calculated by county and SCC from the MOVES run in California, and then applied CARB-provided VOC ($PM_{2.5}$) in the inventory so that California nonroad emissions could be speciated consistently with the rest of the country.

Texas nonroad emissions were provided by the Texas Commission on Environmental Quality for the years 2016, 2023, and 2028, using TCEQ's TexN2 tool.[20] This tool facilitates the use of detailed Texas-specific nonroad equipment population, activity, fuels, and related data as inputs for MOVES2014b, and accounts for Texas-specific emission adjustments such as the Texas Low Emission Diesel (TxLED) program. Texas nonroad emissions were provided seasonally; that is, total emissions for winter, spring, summer and fall; those emissions were evenly distributed between the months in each season. As in California, VOC and $PM_{2.5}$ emissions were allocated to speciation profiles, and VOC HAPs were created, using MOVES data in Texas. For example, ratios of VOC ($PM_{2.5}$) by speciation profile to total VOC ($PM_{2.5}$), and ratios of VOC HAPs to total VOC, were calculated by county and SCC from the MOVES run in Texas, and then applied TCEQ-provided VOC ($PM_{2.5}$) in the inventory so that Texas nonroad emissions could be speciated consistently with the rest of the country.

Nonroad Updates from State Comments

The 2016 Nonroad Collaborative workgroup received a small number of comments on the 2016beta inventory, all of which were addressed and implemented in the 2016v1 nonroad inventory and carried into 2016v2:

- **Georgia Department of Natural Resources:** utilize updated geographic allocation factors (*nrstatesurrogate* table) for the Commercial, Lawn & Garden (commercial, public, and residential), Logging, Manufacturing, Golf Carts, Recreational, Railroad Maintenance Equipment and A/C/Refrigeration sectors, using data from the U.S. Census Bureau and U.S. Forest Service.
- **Lake Michigan Air Directors Consortium (LADCO):** update seasonal allocation of agricultural equipment activity (*nrmonthallocation* table) for Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.
- **Texas Commission on Environmental Quality:** replace MOVES nonroad emissions for Texas with emissions calculated with TCEQ's TexN2 model.
- **Alaska Department of Environmental Conservation:** remove emissions as calculated by MOVES for several equipment sector-county/census areas combinations in Alaska, due to an absence of nonroad activity (see Table 2-29).

Table 2-29. Alaska counties/census areas for which nonroad equipment sector-specific emissions are removed in the 2016 platforms

Nonroad Equipment Sector	Counties/Census Areas (FIPS) for which equipment sector emissions are removed in 2016
Agricultural	Aleutians East (02013), Aleutians West (02016), Bethel Census Area (02050), Bristol Bay Borough (02060), Dillingham Census Area (02070), Haines Borough (02100), Hoonah-Angoon Census Area (02105), Ketchikan Gateway (02130), Kodiak Island Borough (02150), Lake and Peninsula (02164), Nome (02180), North Slope Borough (02185), Northwest Arctic (02188), Petersburg Borough

[20] For more information on the TexN2 tool please see: https://www.tceq.texas.gov/airquality/airmod/overview/am_ei.html and the FTP site amdaftp.tceq.texas.gov/EI/nonroad/TexN2/.

Nonroad Equipment Sector	Counties/Census Areas (FIPS) for which equipment sector emissions are removed in 2016
	(02195), Pr of Wales-Hyder Census Area (02198), Sitka Borough (02220), Skagway Borough (02230), Valdez-Cordova Census Area (02261), Wade Hampton Census Area (02270), Wrangell City + Borough (02275), Yakutat City + Borough (02282), Yukon-Koyukuk Census Area (02290)
Logging	Aleutians East (02013), Aleutians West (02016), Nome (02180), North Slope Borough (02185), Northwest Arctic (02188), Wade Hampton Census Area (02270)
Railway Maintenance	Aleutians East (02013), Aleutians West (02016), Bethel Census Area (02050), Bristol Bay Borough (02060), Dillingham Census Area (02070), Haines Borough (02100), Hoonah-Angoon Census Area (02105), Juneau City + Borough (02110), Ketchikan Gateway (02130), Kodiak Island Borough (02150), Lake and Peninsula (02164), Nome (02180),), North Slope Borough (02185), Northwest Arctic (02188), Petersburg Borough (02195), Pr of Wales-Hyder Census Area (02198), Sitka Borough (02220), Southeast Fairbanks (02240), Wade Hampton Census Area (02270), Wrangell City + Borough (02275), Yakutat City + Borough (02282), Yukon-Koyukuk Census Area (02290)

2.5 2016 Fires (ptfire-wild, ptfire-rx, ptagfire)

Multiple types of fires are represented in the modeling platform. These include wild and prescribed fires that are grouped into the ptfire-wild and ptfire-rx sectors, and agricultural fires that comprise the ptagfire sector. All ptfire and ptagfire fires are in the United States. Fires outside of the United States are described in the ptfire_othna sector later in this document.

2.5.1 Wild and Prescribed Fires (ptfire)

Wildfires and prescribed burns that occurred during the inventory year are included in the year 2016 version 1 (2016v1) inventory as event and point sources. Only minor adjustments were made to ptfire for 2016v2. These minor adjustments consisted of correcting emissions for the Soberanes fire in California that occurred in summer of 2016 and a few improvements to the spatial allocation of large wildfires (no emissions changed in the cases). For 2016v2, the wildfires and prescribed fires were broken up into two different sectors, ptfire-wild and ptfire-rx, respectively. For 2016v3, the ptfire emissions were unchanged from those used in 2016v2. The point agricultural fires inventory (ptagfire) is described in a separate section. For purposes of emission inventory preparation, wildland fire (WLF) is defined as any non-structure fire that occurs in the wildland. The wildland is defined an area in which human activity and development are essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities. Wildland fire activity is categorized by the conditions under which the fire occurs. These conditions influence important aspects of fire behavior, including smoke emissions.

In the 2016v2 inventory, data processing was conducted differently depending on the fire type, as defined below:

- Wildfire (WF): any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire.
- Prescribed (Rx) fire: any fire intentionally ignited by management actions in accordance with applicable laws, policies, and regulations to meet specific land or resource management objectives. Prescribed fire is one type of fire fuels treatment. Fire fuels treatments are vegetation management activities intended to modify or reduce hazardous fuels. Fuels treatments include prescribed fires, wildland fire use, and mechanical treatment.

The SCCs used for the ptfire sources are shown in Table 2-30. The ptfire inventory includes separate SCCs for the flaming and smoldering combustion phases for wildfire and prescribed burns. Note that prescribed grassland fires or Flint Hills, Kansas have their own SCC in the 2016v2 inventory. The year 2016 fire season also included some major wild grassland fires. These wild grassland fires were assigned the standard wildfire SCCs shown in Table 2-30.

Table 2-30. SCCs included in the 2016 ptfire sector

SCC	Description
2801500170	Grassland fires; prescribed
2810001001	Forest Wildfires; Smoldering; Residual smoldering only (includes grassland wildfires)
2810001002	Forest Wildfires; Flaming (includes grassland wildfires)
2811015001	Prescribed Forest Burning; Smoldering; Residual smoldering only
2811015002	Prescribed Forest Burning; Flaming

National Fire Information Data

Numerous fire information databases are available from U.S. national government agencies. Some of the databases are available via the internet while others must be obtained directly from agency staff. Table 2-31 provides the national fire information databases that were used for the 2016v1 ptfire inventory, including the website where the 2016 data were downloaded.

Table 2-31. National fire information databases used in 2016 ptfire inventory

Dataset Name	Fire Types	Format	Agency	Coverage	Source
Hazard Mapping System (HMS)	WF/RX	CSV	NOAA	North America	https://www.ospo.noaa.gov/Products/land/hms.html
Geospatial Multi-Agency Coordination(GeoMAC)	WF	SHP	USGS	Entire US	https://wildfire.usgs.gov/geomac/GeoMACTransition.shtml, https://data-nifc.opendata.arcgis.com/
Incident Command System Form 209: Incident Status Summary (ICS-209)	WF/RX	CSV	Multi	Entire US	https://famit.nwcg.gov/applications/FAMWeb

Dataset Name	Fire Types	Format	Agency	Coverage	Source
National Association of State Foresters (NASF)	WF	CSV	Multi	Participating US states	https://famit.nwcg.gov/applications/FAMWeb (see Public Access Reports, Free Data Extract, then NASF State Data Extract)
Monitoring Trends in Burn Severity (MTBS)	WF/RX	SHP	USGS, USFS	Entire US	https://www.mtbs.gov/direct-download
Forest Service Activity Tracking System (FACTS)	RX	SHP	USFS	Entire US	Hazardous Fuel Treatment Reduction: Polygon at https://data.fs.usda.gov/geodata/edw/datasets.php
US Fish and Wildland Service (USFWS) fire database	WF/RX	CSV	USFWS	Entire US	Direct communication with USFWS

The Hazard Mapping System (HMS) was developed in 2001 by the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite and Data Information Service (NESDIS) as a tool to identify fires over North America in an operational environment. The system utilizes geostationary and polar orbiting environmental satellites. Automated fire detection algorithms are employed for each of the sensors. When possible, HMS data analysts apply quality control procedures for the automated fire detections by eliminating those that are deemed to be false and adding hotspots that the algorithms have not detected via a thorough examination of the satellite imagery.

The HMS product used for the 2016v1 inventory consisted of daily comma-delimited files containing fire detect information including latitude-longitude, satellite used, time detected, and other information. The Visible Infrared Imaging Radiometer Suite (VIIRS) satellite fire detects were introduced into the HMS in late 2016. Since it was only available for a small portion of the year, the VIIRS fire detects were removed for the entire year for consistency. In the 2016alpha inventory, the grassland fire detects were put in the point agricultural fire sector (ptagfire). As there were a few significant grassland wildfires in Kansas and Oklahoma in year 2016, all grassland fire detects were included in the ptfire sector for the 2016v1 inventory. These grassland fires were processed through Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2) and BlueSky Framework.

GeoMAC (Geospatial Multi-Agency Coordination) is an online wildfire mapping application designed for fire managers to access maps of current U.S. fire locations and perimeters. The wildfire perimeter data is based upon input from incident intelligence sources from multiple agencies, GPS data, and infrared (IR) imagery from fixed wing and satellite platforms.

The Incident Status Summary, also known as the "ICS-209" is used for reporting specific information on significant fire incidents. The ICS-209 report is a critical interagency incident reporting tool giving daily 'snapshots' of the wildland fire management situation and individual incident information which include fire behavior, size, location, cost, and other information. Data from two tables in the ICS-209 database were merged and used for the 2016v1 ptfire inventory: the SIT209_HISTORY_INCIDENT_209_REPORTS table contained daily 209 data records for large fires, and the SIT209_HISTORY_INCIDENTS table contained summary data for additional smaller fires.

The National Association of State Foresters (NASF) is a non-profit organization composed of the directors of forestry agencies in the states, U.S. territories, and District of Columbia to manage and protect state and private forests, which encompass nearly two-thirds of the nation's forests. The NASF compiles fire incident reports from agencies in the organization and makes them publicly available. The NASF fire information includes dates of fire activity, acres burned, and fire location information.

Monitoring Trends in Burn Severity (MTBS) is an interagency program whose goal is to consistently map the burn severity and extent of large fires across the U.S. from 1984 to present. The MTBS data includes all fires 1,000 acres or greater in the western United States and 500 acres or greater in the eastern United States. The extent of coverage includes the continental U.S., Alaska, Hawaii, and Puerto Rico. Fire occurrence and satellite data from various sources are compiled to create numerous MTBS fire products. The MTBS Burned Areas Boundaries Dataset shapefiles include year 2016 fires and that are classified as either wildfires, prescribed burns or unknown fire types. The unknown fire type shapes were omitted in the 2016v1 inventory development due to temporal and spatial problems found when trying to use these data.

The US Forest Service (USFS) compiles a variety of fire information every year. Year 2016 data from the USFS Natural Resource Manager (NRM) Forest Activity Tracking System (FACTS) were acquired and used for 2016v1 emissions inventory development. This database includes information about activities related to fire/fuels, silviculture, and invasive species. The FACTS database consists of shapefiles for prescribed burns that provide acres burned, and start and ending time information.

The US Fish and Wildland Service (USFWS) also compiles wildfire and prescribed burn activity on their federal lands every year. Year 2016 data were acquired from USFWS through direct communication with USFWS staff and were used for 2016v1 emissions inventory development. The USFWS fire information provided fire type, acres burned, latitude-longitude, and start and ending times.

State/Local/Tribal Fire Information

During the 2016 emissions modeling platform development process, S/L/T agencies were invited by EPA and 2016 Inventory Collaborative Fire Workgroup to submit all fire occurrence data for use in developing the 2016v1 fire inventory. A template form containing the desired format for data submittals was provided to S/L/T air agencies. The list of S/L/T agencies that submitted fire data is provided in Table 2-32. Data from nine individual states and one Indian Tribe were used for the 2016v1 ptfire inventory.

Table 2-32. List of S/L/T agencies that submitted fire data for 2016v1 with types and formats.

S/L/T agency name	Fire Types	Format
NCDEQ	WF/RX	CSV
KDHE	RX/AG	CSV
CO Smoke Mgmt Program	RX	CSV
Idaho DEQ	AG	CSV
Nez Perce Tribe	AG	CSV
GA DNR	ALL	EIS
MN	RX/AG	CSV
WA ECY	AG	CSV

S/L/T agency name	Fire Types	Format
NJ DEP	WF/RX	CSV
Alaska DEC	WF/RX	CSV

The data provided by S/L/T agencies were evaluated by EPA and further feedback on the data submitted by the state was requested at times. Table 2-33 provides a summary of the type of data submitted by each S/L/T agency and includes spatial, temporal, acres burned and other information provided by the agencies.

Table 2-33. Brief description of fire information submitted for 2016v1 inventory use.

S/L/T agency name	Fire Types	Description
NCDEQ	WF/RX	Fire type, period-specific, latitude-longitude and acres burned information. Technical direction was to remove all fire detects that were not reconciled with any other national or state agency database.
Kansas DHE	RX/AG	Day-specific, county-centroid located, acres burned for Flint Hills prescribed burns for Feb 27-May 4 time period. Reclassified fuels for some agricultural burns. A grassland gridding surrogate was used to spatially allocate the day-specific grassland fire emissions.
Colorado Smoke Mgmt Program	RX	Day-specific, latitude-longitude, and acres burned for prescribed burns
Idaho DEQ	AG	Day-specific, latitude-longitude, acres burned for agricultural burns. Total replacement of 2016 alpha fire inventory for Idaho.
Nez Perce Tribe	AG	Day-specific, latitude-longitude, acres burned for agricultural burns. Total replacement of 2016 alpha fire inventory within the tribal area boundary.
Georgia DNR	ALL	Data submitted included all fires types via EIS. The wildfire and prescribed burn data were provided as daily, point emissions sources. The agricultural burns were provided as day-specific point emissions sources.
Minnesota	RX/AG	Corrected latitude-longitude, day-specific and acres burned for some prescribed and agricultural burns.
Washington ECY	AG	Month-specific, latitude-longitude, acres burned, fuel loading and emissions for agricultural burns. Not day-specific so allocation to daily implemented by EPA. WA state direction included to continue to use the 2014NEIv2 pile burns that were included in the non-point sector for 2016v1.
New Jersey DEP	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns.
Alaska DEC	WF/RX	Day-specific, latitude-longitude, and acres burned for wildfire and prescribed burns.

Fire Emissions Estimation Methodology

The national and S/L/T data mentioned earlier were used to estimate daily wildfire and prescribed burn emissions from flaming combustion and smoldering combustion phases for the 2016v1 inventory. Flaming combustion is more complete combustion than smoldering and is more prevalent with fuels that have a high surface-to-volume ratio, a low bulk density, and low moisture content. Smoldering combustion occurs without a flame, is a less complete burn, and produces some pollutants, such as PM2.5, VOCs, and CO, at higher rates than flaming combustion. Smoldering combustion is more prevalent with fuels that have low surface-to-volume ratios, high bulk density, and high moisture content. Models sometimes differentiate between smoldering emissions that are lofted with a smoke plume and those that remain near the ground (residual emissions), but for the purposes of the 2016v1 inventory the residual smoldering emissions were allocated to the smoldering SCCs listed in Table 2-30. The lofted smoldering emissions were assigned to the flaming emissions SCCs in Table 2-30.

Figure 2-10 is a schematic of the data processing stream for the 2016v1 inventory for wildfire and prescribe burn sources. The ptfire inventory sources were estimated using Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2) and BlueSky Framework. SMARTFIRE2 is an algorithm and database system that operate within a geographic information system (GIS). SMARTFIRE2 combines multiple sources of fire information and reconciles them into a unified GIS database. It reconciles fire data from space-borne sensors and ground-based reports, thus drawing on the strengths of both data types while avoiding double-counting of fire events. At its core, SMARTFIRE2 is an association engine that links reports covering the same fire in any number of multiple databases. In this process, all input information is preserved, and no attempt is made to reconcile conflicting or potentially contradictory information (for example, the existence of a fire in one database but not another).

For the 2016v1 inventory, the national and S/L/T fire information was input into SMARTFIRE2 and then merged and associated based on user-defined weights for each fire information dataset. The output from SMARTFIRE2 was daily acres burned by fire type, and latitude-longitude coordinates for each fire. The fire type assignments were made using the fire information datasets. If the only information for a fire was a satellite detect for fire activity, then the flow described in Figure 2-11 was used to make fire type assignment by state and by month.

Figure 2-10. Processing flow for fire emission estimates in the 2016 inventory

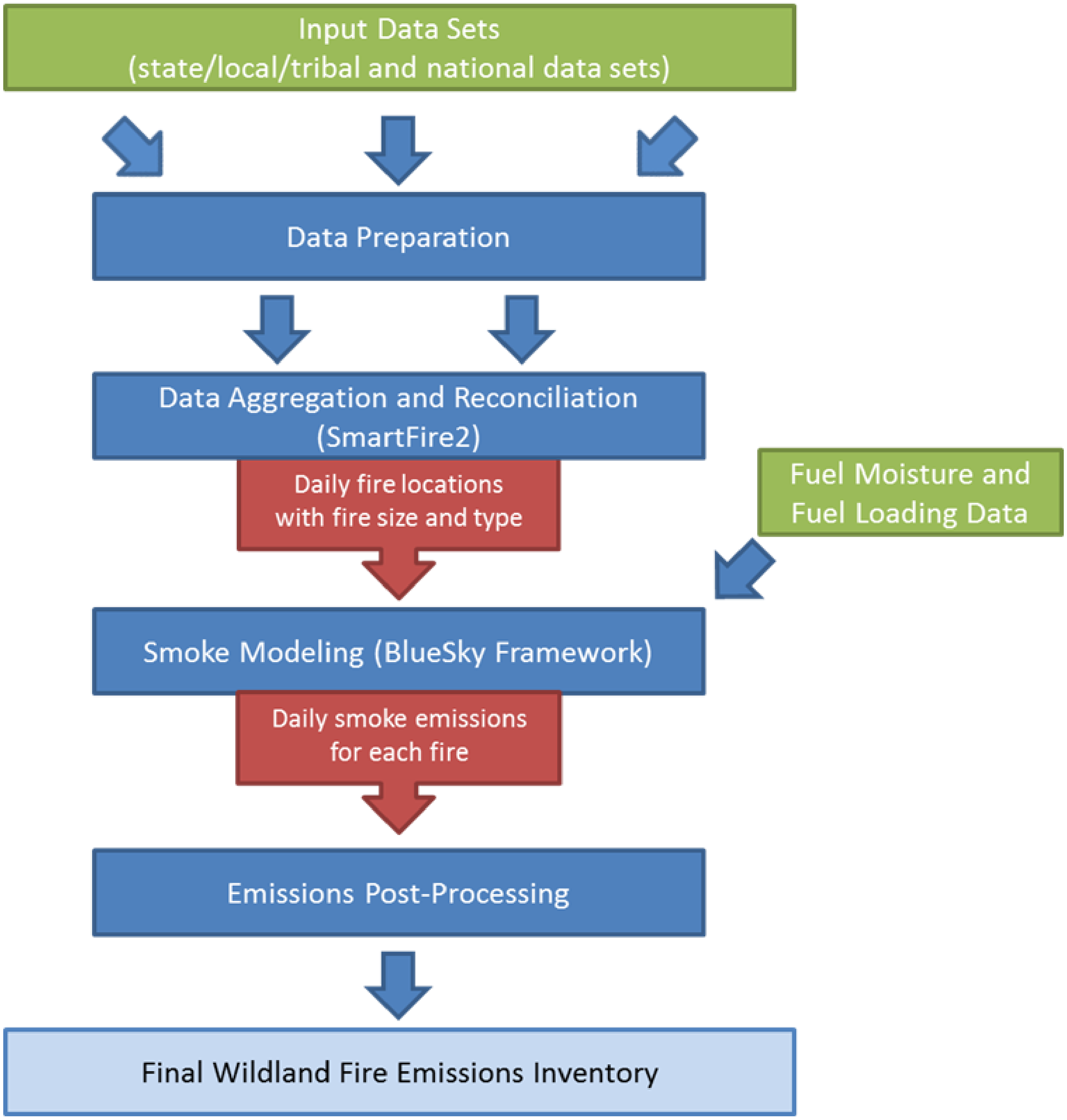
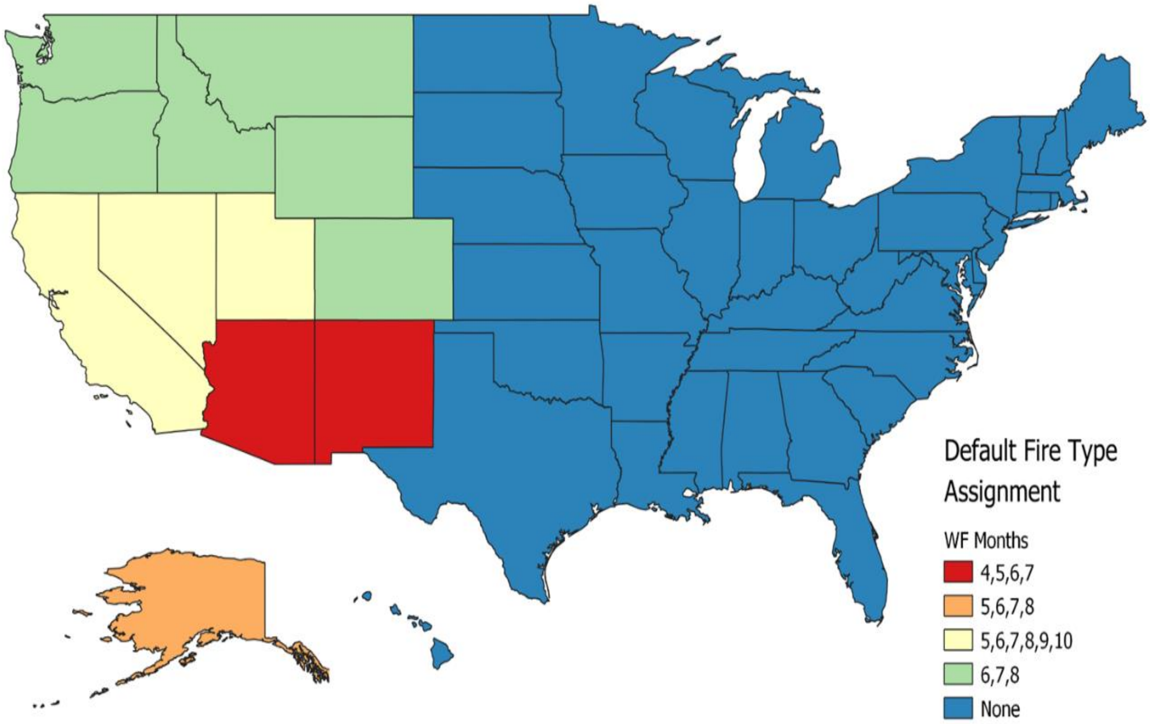


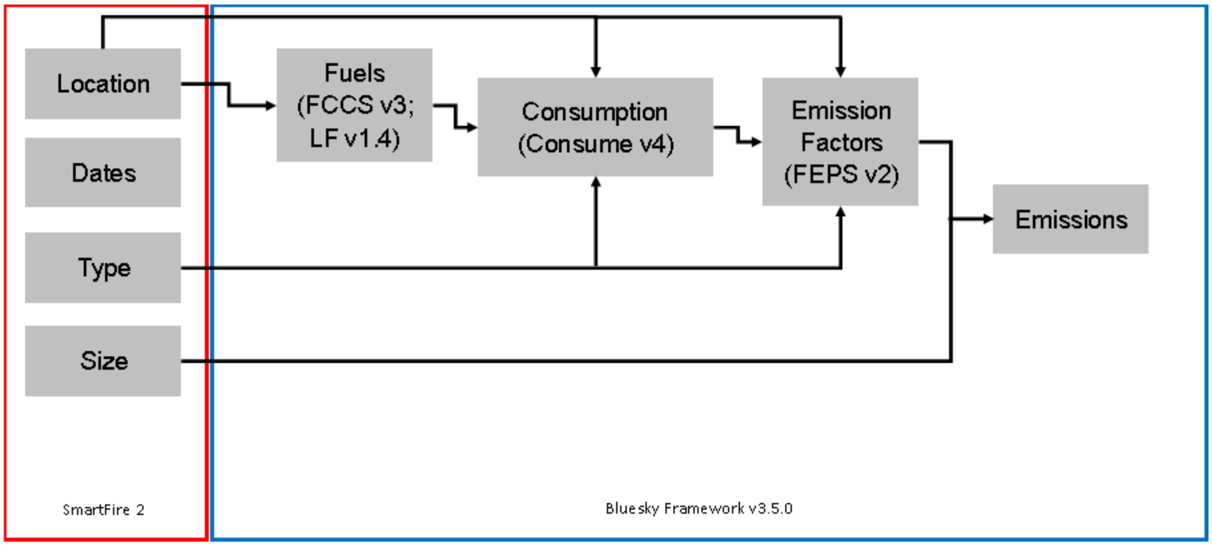
Figure 2-11. Default fire type assignment by state and month where data are only from satellites.



The BlueSky Modeling Framework version 3.5 (revision #38169) was used to calculate fuel loading and consumption, and emissions using various models depending on the available inputs as well as the desired results. The contiguous United States and Alaska, where Fuel Characteristic Classification System (FCCS) fuel loading data are available, were processed using the modeling chain described in Figure 2-12. The Fire Emissions Production Simulator (FEPS) in the BlueSky Framework generated the CAP emission factors for wildland fires used in the 2016v1 inventory. The HAPs were derived from regional emissions factors from Urbanski (2014).

For the 2016v1 inventory, the FCCSv2 spatial vegetation cover was upgraded to the LANDFIRE v1.4 fuel vegetation cover (See: https://www.landfire.gov/fccs.php). The FCCSv3 fuel bed characteristics were implemented along with LANDFIREv1.4 to provide better fuel classification for the BlueSky Framework. The LANDFIREv1.4 raster data were aggregated from the native resolution and projection to 200 meter resolution using a nearest-neighbor methodology. Aggregation and reprojection were required to facilitate the use of these data in the BlueSky Framework.

Figure 2-12. BlueSky Modeling Framework



2.5.2 Point Source Agricultural Fires (ptagfire)

The point source agricultural fire (ptagfire) inventory sector contains daily agricultural burning emissions. Daily fire activity was derived from the NOAA Hazard Mapping System (HMS) fire activity data. The agricultural fires sector includes SCCs starting with '28015'. The first three levels of descriptions for these SCCs are: 1) Fires - Agricultural Field Burning; Miscellaneous Area Sources; 2) Agriculture Production - Crops - as nonpoint; and 3) Agricultural Field Burning - whole field set on fire. The SCC 2801500000 does not specify the crop type or burn method, while the more specific SCCs specify field or orchard crops and, in some cases, the specific crop being grown. The SCCs for this sector listed are in Table 2-34. For 2016v3, the ptagfire data are unchanged from 2016v2.

Table 2-34. SCCs included in the 2016 ptagfire sector

SCC	Description
2801500000	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Unspecified crop type and Burn Method
2801500100	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crops Unspecified
2801500112	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Alfalfa: Backfire Burning
2801500130	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Barley: Burning Techniques Not Significant
2801500141	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Bean (red): Headfire Burning
2801500150	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Corn: Burning Techniques Not Important
2801500151	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Double Crop Winter Wheat and Corn

SCC	Description
2801500152	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;DoubleCrop Corn and Soybeans
2801500160	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Cotton: Burning Techniques Not Important
2801500170	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Grasses: Burning Techniques Not Important
2801500171	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Fallow
2801500182	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Hay (wild): Backfire Burning
2801500202	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Pea: Backfire Burning
2801500220	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Rice: Burning Techniques Not Significant
2801500250	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Sugar Cane: Burning Techniques Not Significant
2801500262	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Field Crop is Wheat: Backfire Burning
2801500263	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;DoubleCrop Winter Wheat and Cotton
2801500264	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;DoubleCrop Winter Wheat and Soybeans
2801500300	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Orchard Crop Unspecified
2801500320	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Orchard Crop is Apple
2801500350	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Orchard Crop is Cherry
2801500410	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Orchard Crop is Peach
2801500420	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Orchard Crop is Pear
2801500500	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Vine Crop Unspecified
2801500600	Miscellaneous Area Sources;Agriculture Production - Crops - as nonpoint;Agricultural Field Burning - whole field set on fire;Forest Residues Unspecified

The EPA estimated biomass burning emissions using remote sensing data. These estimates were then reviewed by the states and revised as resources allowed. As many states did not have the resources to estimate emissions for this sector, remote sensing was necessary to fill in the gaps for regions where there was no other source of data. Crop residue emissions result from either pre-harvest or post-harvest burning of agricultural fields. The crop residue emission inventory for 2016 is day-specific and includes geolocation information by crop type. The method employed and described here is based on the same methods employed in the 2014 NEI with a few minor updates. It should be noted that grassland fires were moved from the agricultural burning inventory sector to the prescribed and wildland fire sector for 2016beta and 2016v1 inventories. This was done to prevent double-counting of fires and because the largest fire (acres burned) in 2016 was a wild grassland fire in Kansas.

Daily, year-specific agricultural burning emissions were derived from HMS fire activity data, which contains the date and location of remote-sensed anomalies. As point source inventories, the locations of the fires are identified with latitude-longitude coordinates for specific fire events. The HMS activity data were filtered using 2016 USDA cropland data layer (CDL). Satellite fire detects over agricultural lands were assumed to be agricultural burns and assigned a crop type. Detects that were not over agricultural lands were output to a separate file for use in the point source wildfire (ptfire) inventory sector. Each detect was assigned an average size of between 40 and 80 acres based on crop type. The assumed field sizes are found in Table 2-35.

Table 2-35. Assumed field size of agricultural fires per state(acres)

State	Field Size
Alabama	40
Arizona	80
Arkansas	40
California	120
Colorado	80
Connecticut	40
Delaware	40
Florida	60
Georgia	40
Idaho	120
Illinois	60
Indiana	60
Iowa	60
Kansas	80
Kentucky	40
Louisiana	40
Maine	40
Maryland	40
Massachusetts	40
Michigan	40
Minnesota	60
Mississippi	40
Missouri	60
Montana	120
Nebraska	60
Nevada	40
New Hampshire	40

State	Field Size
New Jersey	40
New Mexico	80
New York	40
North Carolina	40
North Dakota	60
Ohio	40
Oklahoma	80
Oregon	120
Pennsylvania	40
Rhode Island	40
South Carolina	40
South Dakota	60
Tennessee	40
Texas	80
Utah	40
Vermont	40
Virginia	40
Washington	120
West Virginia	40
Wisconsin	40
Wyoming	80

Another feature of the ptagfire database is that the satellite detections for 2016 were filtered out to exclude areas covered by snow during the winter months. To do this, the daily snow cover fraction per grid cell was extracted from a 2016 meteorological Weather Research Forecast (WRF) model simulation. The locations of fire detections were then compared with this daily snow cover file. For any day in which a grid cell had snow cover, the fire detections in that grid cell on that day were excluded from the inventory. Due to the inconsistent reporting of fire detections for year 2016 from the Visible Infrared Imaging Radiometer Suite (VIIRS) platform, any fire detections in the HMS dataset that were flagged as VIIRS or Suomi National Polar-orbiting Partnership satellite were excluded. In addition, certain crop types (corn and soybeans) were excluded from the following states: Iowa, Kansas, Indiana, Illinois, Michigan, Missouri, Minnesota, Wisconsin, and Ohio. Kansas was not included in this list in the 2014NEI but added for 2016. The reason for these crop types being excluded is because states have indicated that these crop types are not burned.

Crop type-specific emissions factors were applied to each daily fire to calculate criteria and hazardous pollutant emissions. In all prior NEIs for this sector, the HAP emission factors and the VOC emission factors were known to be inconsistent. The HAP emission factors were copied from the HAP emission factors for wildfires in the 2014 NEI and in the 2016 beta and version 1 modeling platforms. The VOC emission factors were scaled from the CO emission factors in the 2014 NEI and the 2016 beta and version 1 modeling platforms. See Pouliot et al, 2017 for a complete table of emission factors and fuel loading by crop type.

Heat flux values for computing fire plume rise were calculated using the size and assumed fuel loading of each daily fire. Emission factors and fuel loading by crop type are available in Table 1 of Pouliot et al. (2017). This information is needed for a plume rise calculation within a chemical transport modeling system. In prior year modeling platforms including 2014, all the emissions were placed into layer 1 (i.e. ground level).

The daily agricultural and open burning emissions were converted from a tabular format into the SMOKE-ready daily point Flat File 2010 (FF10) format. The daily emissions were also aggregated into annual values by location and converted into the annual point flat file format.

2.6 2016 Biogenic Sources (beis)

Biogenic emissions for 2016v3 were developed using the Biogenic Emission Inventory System version 4 (BEIS4) within SMOKE. BEIS4 was released with SMOKE 4.9. BEIS4 is most compatible with MCIP v5 meteorological data, although data output from MCIP v5 were not available for the year 2016. Minor modifications were made to BEIS4 to accommodate the use of the available 2016 meteorological data that was processed using MCIP v4.3. The landuse input into BEIS4 was the Biogenic Emissions Landuse Dataset (BELD) version 6. The versions of BEIS and BELD were both updated for 2016v3 platform in response to comments on air quality model performance.

The BELD6 includes the following datasets:

- High resolution tree species and biomass data from Wilson et al. 2013a, and Wilson et al. 2013b for which species names were changed from non-specific common names to scientific names;
- Tree species biogenic volatile organic carbon (BVOC) emission factors for tree species where taken from the NCAR Enclosure database (Wiedinmyer 2001);
- Agricultural land use from US Department of Agriculture (USDA) crop data layer (https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php)
- Global Moderate Resolution Imaging Spectroradiometer (MODIS) 20 category data with enhanced lakes and Fraction of Photosynthetically Active Radiation (FPAR) for vegetation coverage from National Center for Atmospheric Research (NCAR) (https://www2.mmm.ucar.edu/wrf/users/download/get_sources_wps_geog.html)
- Canadian BELD land use (https://www.epa.gov/sites/default/files/2019-08/documents/800am_zhang_2_0.pdf).

BEIS4 has some important updates from earlier versions of BEIS. These include the incorporation of Version 6 of the Biogenic Emissions Landuse Database (BELD6), the option to include seasonality of emissions using the 1 meter soil temperature (SOIT2) instead of the BIOSEASON file, and canopy temperature and radiation environments are now modeled using the driving meteorological model's (WRFv3.8) representation of LAI rather than the estimated LAI values just from BELD data. See https://github.com/USEPA/CMAQ/wiki/CMAQ-Release-Notes:-Emissions-Updates:-BEIS-Biogenic-Emissions for more technical information on BEIS4.

BEIS4 includes a two-layer canopy model. Layer structure varies with light intensity and solar zenith angle. Both layers of the canopy model include estimates of sunlit and shaded leaf area based on solar zenith angle and light intensity, direct and diffuse solar radiation, and leaf temperature (Bash et al., 2016).

The new algorithm requires additional meteorological variables over previous versions of BEIS. The variables output from the Meteorology-Chemistry Interface Processor (MCIP) that are used for BEIS4 processing are shown in Table 2-36. The WSAT_PX variable was not available for the version of WRF and MCIP used in the 2016 modeling platform, as this variable became available with WRFv4 and future versions. For 2016 modeling, minor code modifications were made to BEIS4 to calculate WSAT based on soil type (SLTYP) and soil moisture (SOIM1) in a very similar manner that is done in BEIS3. The WSAT_PX variable only impacts the nitric oxide emissions from soils in BEIS models. The 2016 BEIS4 modeling for year 2016 included processing for both a 36km (36US3) and 12km domain (12US1) (see Figure 3-1). The 12US2 modeling domain can also be supported by taking a subset or window of the 12US1 BEIS4 emissions dataset.

Table 2-36. Hourly Meteorological variables required by BEIS4

Variable	Description
LAI	leaf-area index
PRSFC	surface pressure
Q2	mixing ratio at 2m
RADYNI	inverse of aerodynamic resistance
RC	convective precipitation
RGRND	solar radiation reaching surface
RN	nonconvective precipitation
RSTOMI	inverse of bulk stomatal resistance
SLTYP	soil texture type by USDA category
SOIM1	volumetric soil moisture in top cm
SOIT1	soil temperature in top cm
SOIT2	soil temperature in top m
TEMPG	skin temperature at ground
TEMP2	Temperature at 2m
USTAR	cell averaged friction velocity
WSAT_PX	soil saturation from (Pleim-Xiu Land Surface Model) PX-LSM

Bug fixes included in BEIS4 included the following:

- Solar radiation attenuation in the shaded portion of the canopy was using the direct beam photosynthetically active radiation (PAR) when the diffuse beam PAR attenuation coefficient should have been used.
    - This update had little impact on the total emissions but did result in slightly higher emissions in the morning and evening transition periods for isoprene, methanol and Methylbutenol (MBO).
- The fraction of solar radiation in the sunlit and shaded canopy layers, SOLSUN and SOLSHADE respectively were estimated using a planar surface. These should have been estimated based on the PAR intercepted by a hemispheric surface rather than a plane.
    - This update can result in an earlier peak in leaf temperature, approximately up to an hour.

- The quantum yield for isoprene emissions (ALPHA) was updated to the mean value in Niinemets et al. 2010a (https://doi.org/10.1029/2010JG001436) and the integration coefficient (CL) was updated to yield 1 when PAR = 1000 following Niinemets et al 2010b (https://doi.org/10.5194/bg-7-1809-2010).
    - This updated resulted in a slight reduction in isoprene, methanol, and MBO emissions.

The SMOKE-BEIS4 modeling system consists of two programs named: 1) Normbeis4 and 2) Tmpbeis4. Normbeis4 uses emissions factors and BELD6 landuse and gridded biomass data to compute gridded normalized emissions for chosen model domain (see Figure 2-13). The BEIS4 emissions factor file (BEISFAC) contains leaf-area-indices (LAI), dry leaf biomass, winter biomass factor, indicator of specific leaf weight, Agricultural land type Yes/No (AG_YN), and normalized emission fluxes for 35 different species/compounds. The BELD6 file is the gridded landuse for 200+ different landuse types. The output gridded domain is the same as the input domain for the land use data. Output emission fluxes (BEIS_NORM_EMIS) are normalized to 30°C, and isoprene and methyl-butenol fluxes are also normalized to a photosynthetic active radiation of 1000 μmol/m^2s.

The normalized emissions output from Normbeis4 (BEIS_NORM_EMIS) are input into Tmpbeis4 along with the MCIP meteorological data, chemical speciation profile to use for desired chemical mechanism, and soil moisture data file. Figure 2-14 illustrates the data flows for the Tmpbeis4 program. The output from Tmpbeis includes gridded, speciated, hourly emissions both in moles/second (B4GTS_L) and tons/hour (B4GTS_S). Biogenic emissions do not use an emissions inventory and do not have SCCs. . Please see the SMOKEv4.9 User's Manual for more information on BEIS4 (https://www.cmascenter.org/smoke/documentation/4.9/html/ch04s19.html)

Figure 2-13. Normbeis4 data flows for 2016v3

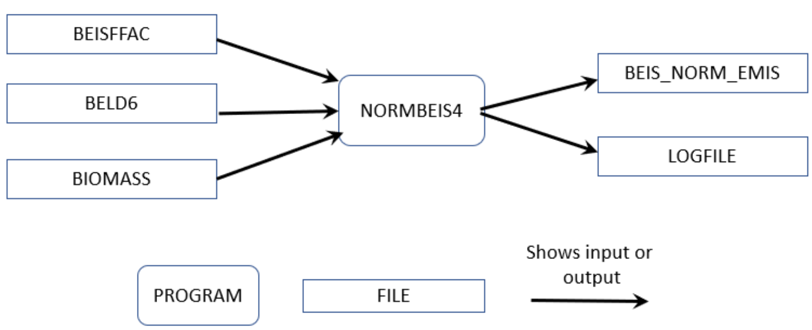
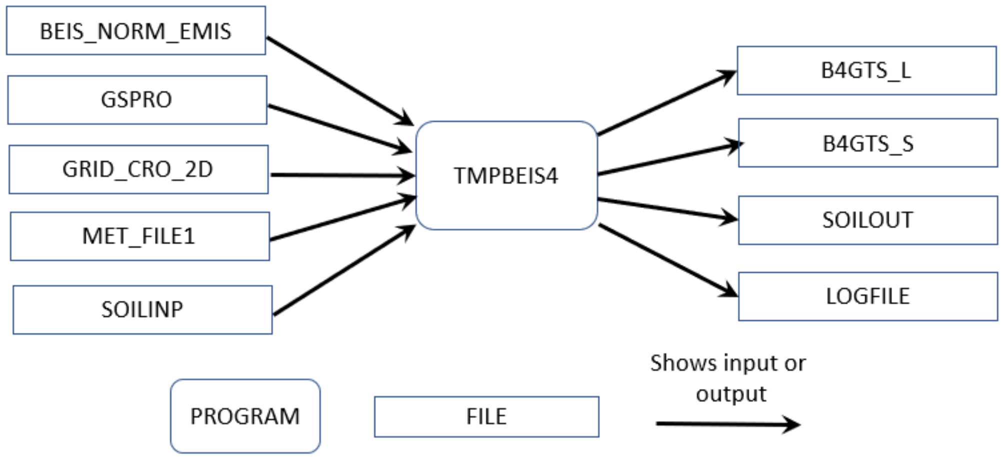


Figure 2-14. Tmpbeis4 data flow diagram for 2016v3



.

2.7 Sources Outside of the United States

The emissions from Canada and Mexico and other areas outside of the U.S. are included in these emissions modeling sectors: othpt, othar, othafdust, othptdust, onroad_can, onroad_mex, and ptfire_othna. The "oth" refers to the fact that these emissions are usually "other" than those in the NEI, and the remaining characters provide the SMOKE source types: "pt" for point, "ar" for "area and nonroad mobile," "afdust" for area fugitive dust (Canada only), and "ptdust" for point fugitive dust. Because Canada and Mexico onroad mobile emissions are modeled differently from each other, they are separated into two sectors: onroad_can and onroad_mex. Additional details for these sectors can be found in the 2016v1 platform specification sheets.

Canadian emissions were taken from the Environment and Climate Change Canada (ECCC) 2016 emission inventory, which was new for the 2016v2 platform. New 2016 emissions were also provided for Mexico by SEMARNAT for 2016v2. The 2016v3 emissions for Canada and Mexico are unchanged from those in the 2016v2 platform.

2.7.1 Point Sources in Canada and Mexico (othpt, canada_ag, canada_og2D)

Canadian point sources were taken from the ECCC 2016 emission inventory, which was new for the 2016v2 platform. The provided point source inventories include upstream oil and gas emissions, agricultural ammonia and VOC. The Mexico point sources were taken from the SEMARNAT 2016 inventory. These inventories were unchanged in the 2016v3 platform.

Due to the large number of points in the Canada inventories, for 2016v2 the agricultural sources were split into a separate sector called canada_ag so that the sources could be placed into layer 1 as plume rise calculations were not needed. Similarly, there were a very large number of Canadian oil and gas point sources, most of which would be appropriate modeled in layer 1. These sources were placed into the canada_og2D sector for layer 1 modeling. Reducing the size of the othpt sector sped up the air quality model run. The Canadian point source inventory is pre-speciated for the CB6 chemical mechanism. Also for Canada, agricultural data were originally provided on a rotated 10-km grid for the 2016beta platform. These were smoothed out to avoid the artifact of grid lines in the processed emissions. The data were monthly resolution for Canadian agricultural and airport emissions, along with some Canadian point sources, and annual resolution for the remainder of Canada and all of Mexico.

2.7.2 Fugitive Dust Sources in Canada (othafdust, othptdust)

Fugitive dust sources of particulate matter emissions excluding land tilling from agricultural activities, were provided by Environment and Climate Change Canada (ECCC) as part of their 2016 emission inventory. Different source categories were provided as gridded point sources and area (nonpoint) source inventories.

Gridded point source emissions resulting from land tilling due to agricultural activities were provided as part of the ECCC 2016 emission inventory. The provided wind erosion emissions were removed. The data were originally provided on a rotated 10-km grid for the 2016 beta platform, but these were smoothed to avoid the artifact of grid lines appearing in the emissions output from SMOKE. The othptdust emissions have a monthly resolution.

A transport fraction adjustment that reduces dust emissions based on land cover types was applied to both point and nonpoint dust emissions, along with a meteorology-based (precipitation and snow/ice cover) zero-out of emissions when the ground is snow covered or wet. There were no updates made to the Canadian dust sources in the 2016v3 platform.

2.7.3 Nonpoint and Nonroad Sources in Canada and Mexico (othar)

ECCC provided year 2016 Canada province, and in some cases sub-province, resolution emissions from for nonpoint and nonroad sources. The nonroad sources were monthly while the nonpoint and rail emissions were annual. For Mexico, the 2016 Mexico nonpoint and nonroad inventories from SEMARNAT were used. All Mexico inventories were annual resolution. Canadian CMV inventories that had been included in the othar sector in past modeling platforms are now included in the cmv_c1c2 and cmv_c3 sectors as point sources. There were no updates made to the other sector emissions in the 2016v3 platform.

2.7.4 Onroad Sources in Canada and Mexico (onroad_can, onroad_mex)

ECCC provided monthly year 2016 onroad emissions for Canada at the province resolution or sub-province resolution depending on the province. For Mexico, monthly year 2016 onroad inventories at the municipio resolution unchanged from 2016v1 were used. The Mexico onroad emissions are based on MOVES-Mexico runs for 2014 and 2017 that were interpolated to 2016.

2.7.5 Fires in Canada and Mexico (*ptfire_othna*)

Annual point source 2016 day-specific wildland emissions for Mexico, Canada, Central America, and Caribbean nations were developed from a combination of the Fire Inventory from NCAR (FINN) daily fire emissions and fire data provided by ECCC when available. ECCC emissions were used for Canada wildland fire emissions for April through November and FINN fire emissions were used to fill in the annual gaps from January through March and December. Only CAP emissions are provided in the ptfire_othna sector inventories. In 2016v2 and 2016v3, the ptfire_othna emissions are unchanged from those used in 2016v1.

For FINN fires, listed vegetation type codes of 1 and 9 are defined as agricultural burning, all other fire detections and assumed to be wildfires. All wildland fires that are not defined as agricultural are assumed to be wildfires rather than prescribed. FINN fire detects less than 50 square meters (0.012 acres) are removed from the inventory. The locations of FINN fires are geocoded from latitude and longitude to FIPS code.

2.7.6 Ocean Chlorine, Sea Salt, and Lightning NOx

The ocean chlorine gas emission estimates are based on the build-up of molecular chlorine (Cl_2) concentrations in oceanic air masses (Bullock and Brehme, 2002). Data at 36 km and 12 km resolution were available and were not modified other than the model-species name "CHLORINE" was changed to "CL2" to support CMAQ modeling. The CL2 emissions are constant in all ocean grid cells. These data are unchanged from the data in 2016v1 and are passed to both CMAQ and CAMx. Separately from the ocean chlorine, CMAQ computes sea salt particulate emissions inline during the model run.

For CAMx modeling, the OCEANIC preprocessor is used to compute emissions for the following pollutants over ocean water: sodium (NA), chlorine (PCL), sulfate (PSO4), dimethy sulfide (DMS), and gas phase bromine (SSBR) and chlorine (SSCL). Additional information is provided in Section 3.5.

The 2016 lightning NOx emissions were created using lightning flashes observed from the World Wide Lightning Location Network (WWLLN, operated by the University of Washington: http://www.wwlln.net). The observed lightning flashes were first gridded into the modeling grid cells as lightning flash density (flashes/km^2•hr), then the flash density was adjusted by applying the deMpas (http://wwlln.net/deMaps) factors to achieve a uniform global detection efficiency (DE) (Hutchins, 2012). The DE-adjusted WWLLN flash density was further scaled using factors derived based on climatological flash density ratios between lightning flashes observed from the National Lightning Detection Network (NLDN), which provides Cloud-to-Ground (CG) lightning observations with a DE of >95% and a location accuracy of about 150 m over the contiguous United States, and the lightning flashes observed from WWLLN. The scale factors vary over the month of the year and grid cell classifications (land versus ocean) (Kang, 2022). The scaled WWLLN (WWLLNs) flash densities were then used as lightning data input to a Fortran program (LNOx generator), that is part of the inline lightning NOx emissions production module in the CMAQ model since CMAQv5.2 but separated from the CMAQ code as a standalone program to generate lightning NOx emissions diagnostic files. To generate the 2D and 3D lightning NOx emissions files, the LNOx generator needs three other input files: METCRO2D to provide the surface pressure and horizontal domain configurations, METCRO3D to provide the vertical structure to distribute LNOx vertically, and a lightning parameter file that contains the geographically distributed climatological CG to cloud-to-cloud lightning flash ratios and the ocean masks (to identify grid cells over land vs over ocean).

3 Emissions Modeling

The CMAQ and CAMx air quality models require hourly emissions of specific gas and particle species for the horizontal and vertical grid cells contained within the modeled region (i.e., modeling domain). To provide emissions in the form and format required by the model, it is necessary to "pre-process" the "raw" emissions (i.e., emissions input to SMOKE) for the sectors described above in Section 2. In brief, the process of emissions modeling transforms the emissions inventories from their original temporal resolution, pollutant resolution, and spatial resolution into the hourly, speciated, gridded and vertical resolution required by the air quality model. Emissions modeling includes temporal allocation, spatial allocation, and pollutant speciation. Emissions modeling sometimes includes the vertical allocation (i.e., plume rise) of point sources, but many air quality models also perform this task because it greatly reduces the size of the input emissions files if the vertical layers of the sources are not included.

As discussed in Section 2, the temporal resolutions of the emissions inventories input to SMOKE vary across sectors and may be hourly, daily, monthly, or annual total emissions. The spatial resolution may be individual point sources; totals by county (U.S.), province (Canada), or municipio (Mexico); or gridded emissions. This section provides some basic information about the tools and data files used for emissions modeling as part of the modeling platform. For additional details that may not be covered in this section, see the specification sheets provided with the 2016v1 platform as many contain additional sector-specific information in spatial allocation, temporal allocation, and speciation that is still relevant for 2016v2 and 2016v3.

3.1 Emissions modeling Overview

SMOKE version 4.9 was used to process the raw emissions inventories into emissions inputs for each modeling sector into a format compatible with CMAQ, which were then converted to CAMx. For sectors that have plume rise, the in-line plume rise capability allows for the use of emissions files that are much smaller than full three-dimensional gridded emissions files. For quality assurance of the emissions modeling steps, emissions totals by specie for the entire model domain are output as reports that are then compared to reports generated by SMOKE on the input inventories to ensure that mass is not lost or gained during the emissions modeling process.

When preparing emissions for the air quality model, emissions for each sector are processed separately through SMOKE, and then the final merge program (Mrggrid) is run to combine the model-ready, sector-specific 2-D gridded emissions across sectors. The SMOKE settings in the run scripts and the data in the SMOKE ancillary files control the approaches used by the individual SMOKE programs for each sector. Table 3-1 summarizes the major processing steps of each platform sector with the columns as follows.

The "Spatial" column shows the spatial approach used: "point" indicates that SMOKE maps the source from a point location (i.e., latitude and longitude) to a grid cell; "surrogates" indicates that some or all of the sources use spatial surrogates to allocate county emissions to grid cells; and "area-to-point" indicates that some of the sources use the SMOKE area-to-point feature to grid the emissions (further described in Section 3.4.2).

The "Speciation" column indicates that all sectors use the SMOKE speciation step, though biogenic speciation is done within the Tmpbeis4 program and not as a separate SMOKE step.

The "Inventory resolution" column shows the inventory temporal resolution from which SMOKE needs to calculate hourly emissions. Note that for some sectors (e.g., onroad, beis), there is no input inventory; instead, activity data and emission factors are used in combination with meteorological data to compute hourly emissions.

Finally, the "plume rise" column indicates the sectors for which the "in-line" approach is used. These sectors are the only ones with emissions in aloft layers based on plume rise. The term "in-line" means that the plume rise calculations are done inside of the air quality model instead of being computed by SMOKE. In all of the "in-line" sectors, all sources are output by SMOKE into point source files which are subject to plume rise calculations in the air quality model. In other words, no emissions are output to layer 1 gridded emissions files from those sectors as has been done in past platforms. The air quality model computes the plume rise using stack parameters, the Briggs algorithm, and the hourly emissions in the SMOKE output files for each emissions sector. The height of the plume rise determines the model layers into which the emissions are placed. The plume top and bottom are computed, along with the plumes' distributions into the vertical layers that the plumes intersect. The pressure difference across each layer divided by the pressure difference across the entire plume is used as a weighting factor to assign the emissions to layers. This approach gives plume fractions by layer and source. Day-specific point fire emissions are treated differently in CMAQ. After plume rise is applied, there are emissions in every layer from the ground up to the top of the plume.

Table 3-1. Key emissions modeling steps by sector.

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
afdust_adj	Surrogates	Yes	Annual	
afdust_ak_adj (36US3 only)	Surrogates	Yes	Annual	
airports	Point	Yes	Annual	None
beis	Pre-gridded land use and biomass data	in BEIS4	computed hourly	
canada_ag	Point	Yes	monthly	None
canada_og2D	Point	Yes	Annual	None
cmv_c1c2	Point	Yes	hourly	in-line
cmv_c3	Point	Yes	hourly	in-line
fertilizer	Surrogates	No	monthly	
livestock	Surrogates	Yes	Annual	
nonpt	Surrogates & area-to-point	Yes	Annual	
nonroad	Surrogates	Yes	monthly	
np_oilgas	Surrogates	Yes	Annual	
np_solvents	Surrogates	Yes	annual	
onroad	Surrogates	Yes	monthly activity, computed hourly	
onroad_ca_adj	Surrogates	Yes	monthly activity, computed hourly	
onroad_nonconus (36US3 only)	Surrogates	Yes	monthly activity, computed hourly	

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
onroad_can	Surrogates	Yes	monthly	
onroad_mex	Surrogates	Yes	monthly	
othafdust_adj	Surrogates	Yes	annual	
othar	Surrogates	Yes	annual & monthly	
othpt	Point	Yes	annual & monthly	in-line
othptdust_adj	Point	Yes	monthly	None
ptagfire	Point	Yes	daily	in-line
pt_oilgas	Point	Yes	annual	in-line
ptegu	Point	Yes	daily & hourly	in-line
ptfire-rx	Point	Yes	daily	in-line
ptfire-wild	Point	Yes	daily	in-line
ptfire_othna	Point	Yes	daily	in-line
ptnonipm	Point	Yes	annual	in-line
rail	Surrogates	Yes	annual	
rwc	Surrogates	Yes	annual	

Biogenic emissions can be modeled two different ways in the CMAQ model. The BEIS model in SMOKE can produce gridded biogenic emissions that are then included in the gridded CMAQ-ready emissions inputs, or alternatively, CMAQ can be configured to create "in-line" biogenic emissions within CMAQ itself. For this platform, biogenic emissions were processed in SMOKE and included in the gridded CMAQ-ready emissions. When CAMx is the targeted air quality model, BEIS is run within SMOKE and the resulting emissions are included with the ground-level emissions input to CAMx.

In 2016v3 platform for the 2016gf case, SMOKE was run in such a way that it produced both diesel and non-diesel outputs for onroad and nonroad emissions that later get merged into the low-level emissions fed into the air quality model. This facilitates advanced speciation treatments that are sometimes used in CMAQ. The onroad emissions were processed in a single sector and were not split between gas a diesel for the 2023gf and 2026gf cases.

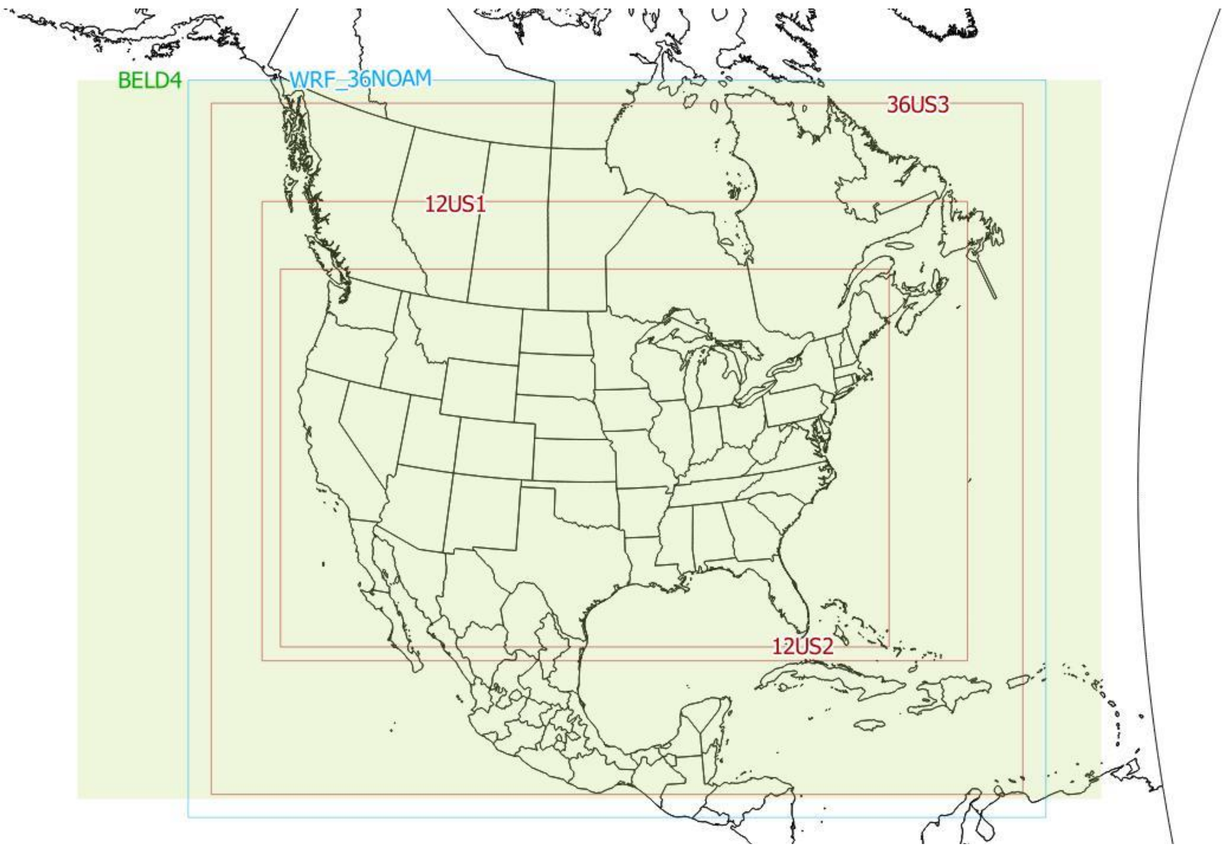
SMOKE has the option of grouping sources so that they are treated as a single stack when computing plume rise. For this platform, no grouping was performed because grouping combined with "in-line" processing will not give identical results as "offline" processing (i.e., when SMOKE creates 3-dimensional files). This occurs when stacks with different stack parameters or latitudes/longitudes are grouped, thereby changing the parameters of one or more sources. The most straightforward way to get the same results between in-line and offline is to avoid the use of grouping.

SMOKE was run for two modeling domains: a 36-km resolution CONtinental United States "CONUS" modeling domain (36US3), and a 12-km resolution domain. Specifically, SMOKE was run on the 12US1 domain and emissions were extracted from 12US1 data files to create 12US2 emissions for 2016, 2023, and 2026. Emissions were developed for 36US3 for 2016 and 2023 only. The outputs of CAMx on the 36US3 grid are used to create boundary conditions for the 12US2 domains. For 2026 , the 2023 boundary conditions were used. The domains are shown in Figure 3-1. All grids use a Lambert-Conformal projection, with Alpha = 33º, Beta = 45º and Gamma = -97º, with a center of X = -97º and Y = 40º. Table 3-2 describes the grids for the three domains.

Table 3-2. Descriptions of the platform grids

Common Name	Grid Cell Size	Description (see Figure 3-1)	Grid name	Parameters listed in SMOKE grid description (GRIDDESC) file: projection name, xorig, yorig, xcell, ycell, ncols, nrows, nthik
Continental 36km grid	36 km	Entire conterminous US, almost all of Mexico, most of Canada (south of 60°N)	36US3	'LAM_40N97W', -2952000, -2772000, 36.D3, 36.D3, 172, 148, 1
Continental 12km grid	12 km	Entire conterminous US plus some of Mexico/Canada	12US1_459X299	'LAM_40N97W', -2556000, -1728000, 12.D3, 12.D3, 459, 299, 1
US 12 km or "smaller" CONUS-12	12 km	Smaller 12km CONUS plus some of Mexico/Canada	12US2	'LAM_40N97W', -2412000 , -1620000, 12.D3, 12.D3, 396, 246, 1

Figure 3-1. Air quality modeling domains



3.2 Chemical Speciation

The emissions modeling step for chemical speciation creates the "model species" needed by the air quality model for a specific chemical mechanism. These model species are either individual chemical compounds (i.e., "explicit species") or groups of species (i.e., "lumped species"). The chemical mechanism used for the 2016 platform is the CB6R3AE7 mechanism (Yarwood, 2010, Luecken, 2019). In CB6R3AE7, additional species that are not included in the CB6 chemical mechanism include acetic acid (ACET), alpha pinene (APIN), formic acid (FACD), and intermediate volatility organic compounds (IVOC). This mapping uses a new systematic methodology for mapping low volatility compounds. Compounds with very low vapor pressure are mapped to model species NVOL and intermediate volatility compounds are mapped to a species called IVOC. In previous mappings, some of these low vapor pressure compounds were mapped to CB6 species. The mechanism and mapping are described in more detail in a memorandum (Ramboll, 2020) describing the mechanism files supplied with the Speciation Tool, the software used to create the CB6 profiles used in SMOKE. It should be noted that the onroad mobile sector does not use this newer mapping because the speciation is done within MOVES and the mapping change was made after MOVES had been run. This platform generates the $PM_{2.5}$ model species associated with the CMAQ Aerosol Module version 7 (AE7).

For 2016v3, the key changes to speciation involved updating some speciation cross references and using newly available speciation profiles for solvents, oil and gas, and some point source SCCs. In addition, the mapping for SOAALK species were updated to exclusively include linear and branched alkanes with more than 8 carbons or cyclic alkanes with more than 6 carbons (Pye, 2012).

Table 3-3 lists the model species produced by SMOKE in the platform used for this study. Updates to species assignments for CB05 and CB6 were made for the 2014v7.1 platform. These continue to be used in the 2016v3 platform and are described in Appendix A.

Table 3-3. Emission model species produced for CB6R3AE7 for CMAQ

Inventory Pollutant	Model Species	Model species description
Cl_2	CL2	Atomic gas-phase chlorine
HCl	HCL	Hydrogen Chloride (hydrochloric acid) gas
CO	CO	Carbon monoxide
NO_X	NO	Nitrogen oxide
NO_X	NO2	Nitrogen dioxide
NO_X	HONO	Nitrous acid
SO_2	SO2	Sulfur dioxide
SO_2	SULF	Sulfuric acid vapor
NH_3	NH3	Ammonia
NH_3	NH3_FERT	Ammonia from fertilizer
VOC	AACD	Acetic acid
VOC	ACET	Acetone
VOC	ALD2	Acetaldehyde
VOC	ALDX	Propionaldehyde and higher aldehydes
VOC	APIN	Alpha pinene
VOC	BENZ	Benzene (not part of CB05)
VOC	CH4	Methane
VOC	ETH	Ethene

Inventory Pollutant	Model Species	Model species description
VOC	ETHA	Ethane
VOC	ETHY	Ethyne
VOC	ETOH	Ethanol
VOC	FACD	Formic acid
VOC	FORM	Formaldehyde
VOC	IOLE	Internal olefin carbon bond (R-C=C-R)
VOC	ISOP	Isoprene
VOC	IVOC	Intermediate volatility organic compounds
VOC	KET	Ketone Groups
VOC	MEOH	Methanol
VOC	NAPH	Naphthalene
VOC	NVOL	Non-volatile compounds
VOC	OLE	Terminal olefin carbon bond (R-C=C)
VOC	PAR	Paraffin carbon bond
VOC	PRPA	Propane
VOC	SESQ	Sesquiterpenes (from biogenics only)
VOC	SOAALK	Secondary Organic Aerosol (SOA) tracer
VOC	TERP	Terpenes (from biogenics only)
VOC	TOL	Toluene and other monoalkyl aromatics
VOC	UNR	Unreactive
VOC	XYLMN	Xylene and other polyalkyl aromatics, minus naphthalene
Naphthalene	NAPH	Naphthalene from inventory
Benzene	BENZ	Benzene from the inventory
Acetaldehyde	ALD2	Acetaldehyde from inventory
Formaldehyde	FORM	Formaldehyde from inventory
Methanol	MEOH	Methanol from inventory
PM_{10}	PMC	Coarse PM > 2.5 microns and ≤ 10 microns
$PM_{2.5}$	PEC	Particulate elemental carbon ≤ 2.5 microns
$PM_{2.5}$	PNO3	Particulate nitrate ≤ 2.5 microns
$PM_{2.5}$	POC	Particulate organic carbon (carbon only) ≤ 2.5 microns
$PM_{2.5}$	PSO4	Particulate Sulfate ≤ 2.5 microns
$PM_{2.5}$	PAL	Aluminum
$PM_{2.5}$	PCA	Calcium
$PM_{2.5}$	PCL	Chloride
$PM_{2.5}$	PFE	Iron
$PM_{2.5}$	PK	Potassium
$PM_{2.5}$	PH2O	Water
$PM_{2.5}$	PMG	Magnesium
$PM_{2.5}$	PMN	Manganese
$PM_{2.5}$	PMOTHR	$PM_{2.5}$ not in other AE6 species
$PM_{2.5}$	PNA	Sodium
$PM_{2.5}$	PNCOM	Non-carbon organic matter
$PM_{2.5}$	PNH4	Ammonium
$PM_{2.5}$	PSI	Silica
$PM_{2.5}$	PTI	Titanium

One additional species in the emissions files but not in the above table is non-methane organic gases (NMOG). This facilitates ongoing advanced work in speciation and is created using an additional GSPRO component that creates NMOG for all TOG and NONHAPTOG profiles plus all integrate HAPs. This species is not used for traditional ozone and particulate matter-focused modeling applications.

The TOG and $PM_{2.5}$ speciation factors that are the basis of the chemical speciation approach for 2016v3 were developed from the SPECIATE 5.2 database (https://www.epa.gov/air-emissions-modeling/speciate-2), the EPA's repository of TOG and PM speciation profiles of air pollution sources. Noting that the 2016v2 platform used profiles from a draft of SPECIATE 5.2. The SPECIATE database development and maintenance is a collaboration involving the EPA’s Office of Research and Development (ORD), Office of Transportation and Air Quality (OTAQ), and the Office of Air Quality Planning and Standards (OAQPS), in cooperation with ECCC (EPA, 2016). The SPECIATE database contains speciation profiles for TOG, speciated into individual chemical compounds, VOC-to-TOG conversion factors associated with the TOG profiles, and speciation profiles for $PM_{2.5}$.

As with previous platforms, some Canadian point source inventories are provided from ECCC as pre-speciated emissions; although not all CB6 species are provided, the inventories were not supplemented with missing species due to the minimal impact of supplementation.

Speciation updates made for 2016v3 platform included:

- Updated assignments to VOC profiles for 6 SCCs (all pulp and paper) and PM2.5 profiles for 3 SCCs (2 pulp and paper, 1 natural gas).
- Updated profile assignments for solvents.
- Re-mapped the profile for SCC 2310010200 from 2487 to 95247.
- Remapped all point and nonpoint SCCs that were mapped to profile 1011 to 95404. The major SCCs mapped to this profile are associated with oil production processes related fugitive leaks/venting. Profile 95404 is a composite profile from untreated oil wells.
- Remapped all point and nonpoint SCCs that were mapped to profile 1207 to profile 95782 (a profile for produced water for non-coal bed methane). These are for non-CBM produced water. We note that CBM produced water is using a Wyoming profile and 95782 is a non-CBM produced water profile also sampled in Wyoming.

Some updates to speciation profiles from previous platforms include the following:

- Additional oil and gas profiles were added (e.g., UTUBOGC, UTUBOGE, UTUBOGF);
- WRAP oil and gas profiles were used for the WRAP oil and gas inventory, although many WRAP profiles were also used in the 2016v1 platform.

Updates to the VOC speciation cross reference implemented in 2016v2 and carried into 2016v3 included:

- changed all 8746 to G8746 (Profile name: Rice Straw and Wheat Straw Burning Composite of G4420 and G4421);
- changed 2104008230/330 from 1084 to 4642 to match all other RWC SCCs (corrections_changes .docx said 4462 but this was an obvious typo and should be 4642);

- changed 2680001000 from 0000 to G95241TOG;
- updated cross reference to use Uinta Basin oil/gas profiles
- substituted profile 95417 with either UTUBOGC (2310010300, 2310011500, 2310111401, 2310010700, 2310010400, 31000107) or UTUBOGD (other SCCs);
- substituted profile 95418 with UTUBOGF;
- substituted profile 95419 with UTUBOGE;
- for Pennsylvania oil and gas profiles, substituted all 8949 with PAGAS01 (FIPS 42059 only), PAGAS02 (FIPS 42019 only), PAGAS03 (FIPS 42125 only);
- for Colorado SCC 2310030300:,Set Archuleta/La Plata to SUIROGWT (counties are in Southern Ute reservation), rest of Colorado to DJTFLR95;
- for Colorado SCC 2310030220: Set to DJTFLR95 (formerly FLR99);
- for Colorado 2310021010: Set Archuleta/La Plata to SUIROGCT (counties are in Southern Ute reservation), rest of Colorado to 95398;
- for SCC 2310000551 (CBM produced water) use the new profile CBMPWWY.

Updates to PM speciation cross references implemented in 2016v2 and carried into 2016v3 included:

- where the comment says the “Heat Treating” profile should be used, changed the profile code to 91123 which is the actual Heat Treating profile;
- for SCC 2801500250, changed to profile SUGP02 (a new sugar cane burning profile);
- for SCC 30400740, changed to profile 95475;
- used new fire profiles for fire PM. Note that all US states (not DC/HI/PR/VI) now use one of the new profiles for all fire SCCs, including grassland fires. The profiles themselves aren't entirely state-specific; there are four representative states for forest fires and two representative states for grass fires, and all states are mapped to one of the four representative forest states and one of the two representative grass states. The GSREFs still have a non-FIPS-specific assignment to the previous profile 3766AE6 for fires outside of the United States.

Speciation profiles and cross-references for this study platform are available in the SMOKE input files for the 2016 platform. Emissions of VOC and $PM_{2.5}$ emissions by county, sector and profile for all sectors other than onroad mobile can be found in the sector summaries for the case. Totals of each model species by state and sector can be found in the state-sector totals workbook for this case.

3.2.1 VOC speciation

The speciation of VOC includes HAP emissions from the NEI in the speciation process. Instead of speciating VOC to generate all species listed in Table 3-3, emissions of five specific HAPs from the NEI were “integrated” with the NEI VOC. These HAPs include naphthalene, benzene, acetaldehyde, formaldehyde and methanol (collectively known as “NBAFM”). The integration combines these HAPs with the VOC in a way that does not double count emissions and uses the HAP inventory directly in the speciation process. The basic process is to subtract the specified HAPs emissions mass from the VOC emissions mass, and to use a special “integrated” profile to speciate the remainder of VOC to the model species excluding the specific HAPs. The EPA believes that the HAP emissions in the NEI are often more representative of emissions than HAP emissions generated via VOC speciation, although this varies by sector.

The NBAFM HAPs were chosen for integration because they are the only explicit VOC HAPs in the CMAQ version 5.2. Explicit means that they are not lumped chemical groups like PAR, IOLE and several other CB6 model species. These "explicit VOC HAPs" are model species that participate in the modeled chemistry using the CB6 chemical mechanism. The use of inventory HAP emissions along with VOC is called "HAP-CAP integration."

The integration of HAPs with VOC is a feature available in SMOKE for all inventory formats, including PTDAY (the format used for the ptfire and ptagfire sectors). The ability to use integration with the PTDAY format is used for the ptfire-rx and ptfire-wild sectors in the 2016 platform, but not for the ptagfire sector which does not include HAPs. SMOKE allows the user to specify the particular HAPs to integrate via the INVTABLE. This is done by setting the "VOC or TOG component" field to "V" for all HAP pollutants chosen for integration. SMOKE allows the user to also choose the particular sources to integrate via the NHAPEXCLUDE file (which actually provides the sources to be *excluded* from integration[21]). For the "integrated" sources, SMOKE subtracts the "integrated" HAPs from the VOC (at the source level) to compute emissions for the new pollutant "NONHAPVOC." The user provides NONHAPVOC-to-NONHAPTOG factors and NONHAPTOG speciation profiles.[22] SMOKE computes NONHAPTOG and then applies the speciation profiles to allocate the NONHAPTOG to the other air quality model VOC species not including the integrated HAPs. After determining if a sector is to be integrated, if all sources have the appropriate HAP emissions, then the sector is considered fully integrated and does not need a NHAPEXCLUDE file. If, on the other hand, certain sources do not have the necessary HAPs, then an NHAPEXCLUDE file must be provided based on the evaluation of each source's pollutant mix. The EPA considered CAP-HAP integration for all sectors in determining whether sectors would have full, no or partial integration (see Figure 3-2). For sectors with partial integration, all sources are integrated other than those that have either the sum of NBAFM > VOC or the sum of NBAFM = 0.

In this platform, NBAFM species are created from the no-integrate source VOC emissions using speciation profiles and do not use HAPs from the inventory. Figure 3-2 illustrates the integrate and no-integrate processes for U.S. Sources. Since Canada and Mexico inventories do not contain HAPs, we use the approach of generating the HAPs via speciation, except for Mexico onroad mobile sources where emissions for integrate HAPs were available.

It should be noted that even though NBAFM were removed from the SPECIATE profiles used to create the GSPRO for both the NONHAPTOG TOG profiles, there still may be small fractions for "BENZ", "FORM", "ALD2", and "MEOH" present. This is because these model species may have come from species in SPECIATE that are mixtures. The quantity of these model species is expected to be very small compared to the BAFM in the NEI. There are no NONHAPTOG profiles that produce "NAPH."

[21] Since SMOKE version 3.7, the options to specify sources for integration are expanded so that a user can specify the particular sources to include or exclude from integration, and there are settings to include or exclude all sources within a sector. In addition, the error checking is significantly stricter for integrated sources. If a source is supposed to be integrated, but it is missing NBAFM or VOC, SMOKE will now raise an error.

[22] These ratios and profiles are typically generated from the Speciation Tool when it is run with integration of a specified list of pollutants, for example NBAFM.

In SMOKE, the INVTABLE allows the user to specify the HAPs to integrate. Two different INVTABLE files were used for different sectors of the platform. For sectors that had no integration across the entire sector (see Table 3-4), a "no HAP use" INVTABLE in which the "KEEP" flag was set to "N" for NBAFM pollutants was used. Thus, any NBAFM pollutants in the inventory input into SMOKE are automatically dropped. This approach both avoids double-counting of these species and assumes that the VOC speciation is the best available approach for these species for sectors using this approach. The second INVTABLE, used for sectors in which one or more sources are integrated, causes SMOKE to keep the inventory NBAFM pollutants and indicates that they are to be integrated with VOC. This is done by setting the "VOC or TOG component" field to "V" for all five HAP pollutants. For the onroad and nonroad sectors, "full integration" includes the integration of benzene, 1,3 butadiene, formaldehyde, acetaldehyde, naphthalene, acrolein, ethyl benzene, 2,2,4-Trimethylpentane, hexane, propionaldehyde, styrene, toluene, xylene, and methyl tert-butyl ether (MTBE).

Figure 3-2. Process of integrating NBAFM with VOC for use in VOC Speciation

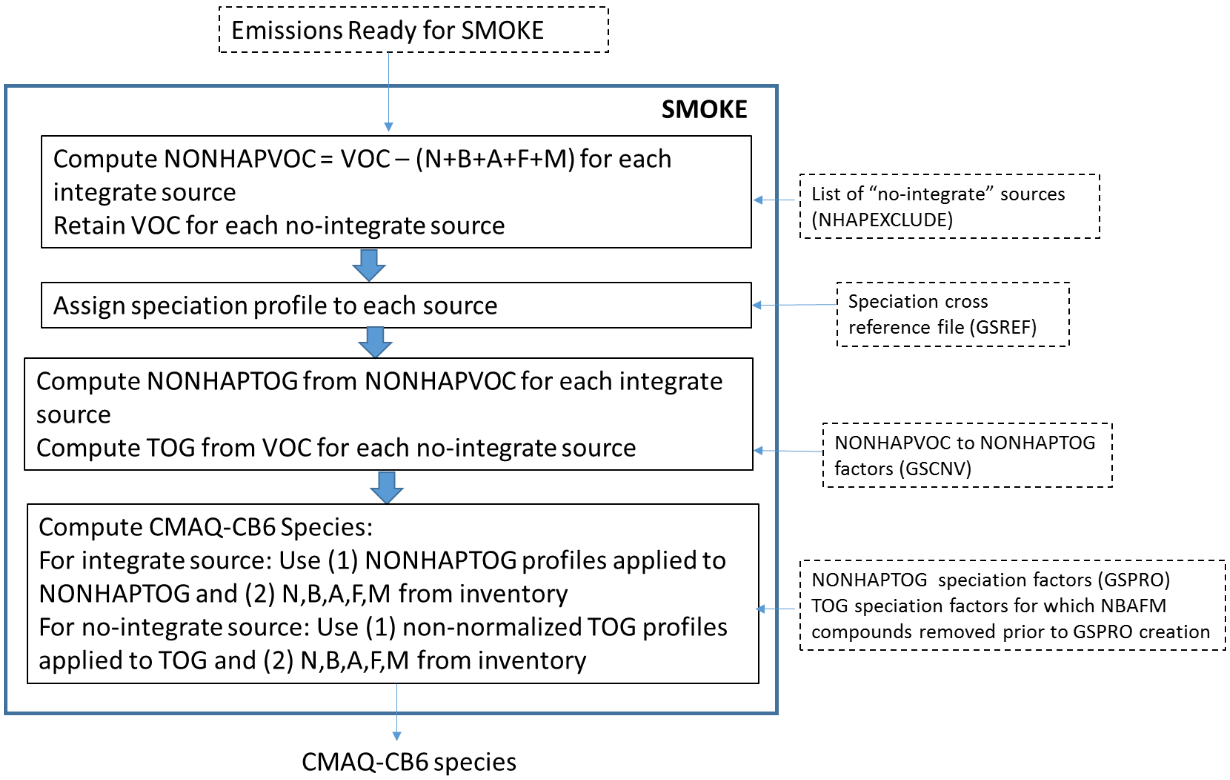


Table 3-4. Integration status of naphthalene, benzene, acetaldehyde, formaldehyde and methanol (NBAFM) for each platform sector

Platform Sector	Approach for Integrating NEI emissions of Naphthalene (N), Benzene (B), Acetaldehyde (A), Formaldehyde (F) and Methanol (M)
ptegu	No integration, create NBAFM from VOC speciation
ptnonipm	No integration, create NBAFM from VOC speciation
ptfire-rx	Partial integration (NBAFM)
ptfire-wild	Partial integration (NBAFM)

Platform Sector	Approach for Integrating NEI emissions of Naphthalene (N), Benzene (B), Acetaldehyde (A), Formaldehyde (F) and Methanol (M)
ptfire_othna	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
ptagfire	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
airports	No integration, create NBAFM from VOC speciation
afdust	N/A – sector contains no VOC
beis	N/A – sector contains no inventory pollutant “VOC”; but rather specific VOC species
cmv_c1c2	Full integration (NBAFM)
cmv_c3	Full integration (NBAFM)
fertilizer	N/A – sector contains no VOC
livestock	Partial integration (NBAFM)
rail	Full integration (NBAFM)
nonpt	Partial integration (NBAFM)
np_solvents	Partial integration (NBAFM)
nonroad	Full integration (internal to MOVES)
np_oilgas	Partial integration (NBAFM)
othpt	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
pt_oilgas	No integration, create NBAFM from VOC speciation
rwc	Partial integration (NBAFM)
onroad	Full integration (internal to MOVES); however, MOVES2014a speciation was CB6-CAMx, not CB6-CMAQ, so post-SMOKE emissions were converted to CB6-CMAQ
onroad_can	No integration, no NBAFM in inventory, create NBAFM from speciation
onroad_mex	Full integration (internal to MOVES-Mexico); however, MOVES-MEXICO speciation was CB6-CAMx, not CB6-CMAQ, so post-SMOKE emissions were converted to CB6-CMAQ
othafdust	N/A – sector contains no VOC
othptdust	N/A – sector contains no VOC
othar	No integration, no NBAFM in inventory, create NBAFM from VOC speciation
canada_ag	No integration, no NBAFM in inventory, create NBAFM from speciation
canada_og2D	No integration, no NBAFM in inventory, create NBAFM from speciation

Integration for the mobile sources estimated from MOVES (onroad and nonroad sectors, other than for California) is done differently. Briefly, there are three major differences: 1) for these sources integration is done using more than just NBAFM, 2) all sources from the MOVES model are integrated, and 3) integration is done fully or partially within MOVES. For onroad mobile, speciation is done fully within MOVES3 such that the MOVES model outputs emission factors for individual VOC model species along with the HAPs. This requires MOVES to be run for a specific chemical mechanism. For this platform MOVES was run for the CB6R3AE7 mechanism. Following the run of SMOKE-MOVES, NMOG emissions were added to the data files through a post-SMOKE processor.

For nonroad mobile, speciation is partially done within MOVES such that it does not need to be run for a specific chemical mechanism. For nonroad, MOVES outputs emissions of HAPs and NONHAPTOG are split by speciation profile. Taking into account that integrated species were subtracted out by MOVES already, the appropriate speciation profiles are then applied in SMOKE to get the VOC model species. HAP integration for nonroad uses the same additional HAPs and ethanol as for onroad.

3.2.1.1 County specific profile combinations

SMOKE can compute speciation profiles from mixtures of other profiles in user-specified proportions via two different methods. The first method, which uses a GSPRO_COMBO file, has been in use since the 2005 platform; the second method (GSPRO with fraction) was used for the first time in the 2014v7.0

platform. The GSPRO_COMBO method uses profile combinations specified in the GSPRO_COMBO ancillary file by pollutant (which can include emissions mode, e.g., EXH__VOC), state and county (i.e., state/county FIPS code) and time period (i.e., month). Different GSPRO_COMBO files can be used by sector, allowing for different combinations to be used for different sectors; but within a sector, different profiles cannot be applied based on SCC. The GSREF file indicates that a specific source uses a combination file with the profile code "COMBO." SMOKE computes the resultant profile using the fraction of each specific profile assigned by county, month and pollutant.

Starting with the 2016v7.2 beta and regional haze platforms, a GSPRO_COMBO is used to specify a mix of E0 and E10 fuels in Canada. ECCC provided percentages of ethanol use by province, and these were converted into E0 and E10 splits. For example, Alberta has 4.91% ethanol in its fuel, so we applied a mix of 49.1% E10 profiles (4.91% times 10, since 10% ethanol would mean 100% E10), and 50.9% E0 fuel. Ethanol splits for all provinces in Canada are listed in Table 3-5. The Canadian onroad inventory includes four distinct FIPS codes in Ontario, allowing for application of different E0/E10 splits in Southern Ontario versus Northern Ontario. In Mexico, only E0 profiles are used.

Table 3-5. Ethanol percentages by volume by Canadian province

Province	Ethanol % by volume (E10 = 10%)
Alberta	4.91%
British Columbia	5.57%
Manitoba	9.12%
New Brunswick	4.75%
Newfoundland & Labrador	0.00%
Nova Scotia	0.00%
NW Territories	0.00%
Nunavut	0.00%
Ontario (Northern)	0.00%
Ontario (Southern)	7.93%
Prince Edward Island	0.00%
Québec	3.36%
Saskatchewan	7.73%
Yukon	0.00%

A new method to combine multiple profiles became available in SMOKE4.5. It allows multiple profiles to be combined by pollutant, state and county (i.e., state/county FIPS code) and SCC. This was used specifically for the oil and gas sectors (pt_oilgas and np_oilgas) because SCCs include both controlled and uncontrolled oil and gas operations which use different profiles.

3.2.1.2 Additional sector specific considerations for integrating HAP emissions from inventories into speciation

The decision to integrate HAP emissions into the speciation was made on a sector-by-sector basis. For some sectors, there is no integration and VOC is speciated directly; for some sectors, there is full integration meaning all sources are integrated; and for other sectors, there is partial integration, meaning some sources are not integrated and other sources are integrated. The integrated HAPs are either NBAFM or, in the case of MOVES (onroad, nonroad, and MOVES-Mexico), a larger set of HAPs plus ethanol are integrated. Table 3-4 above summarizes the integration method for each platform sector.

Speciation for the onroad sector is unique. First, SMOKE-MOVES is used to create emissions for these sectors and both the MEPROC and INVTABLE files are involved in controlling which pollutants are processed. Second, the speciation occurs within MOVES itself, not within SMOKE. The advantage of using MOVES to speciate VOC is that during the internal calculation of MOVES, the model has complete information on the characteristics of the fleet and fuels (e.g., model year, ethanol content, process, etc.), thereby allowing it to more accurately make use of specific speciation profiles. This means that MOVES produces emission factor tables that include inventory pollutants (e.g., TOG) and model-ready species (e.g., PAR, OLE, etc).[23] SMOKE essentially calculates the model-ready species by using the appropriate emission factor without further speciation.[24] Third, MOVES' internal speciation uses full integration of an extended list of HAPs beyond NBAFM (called "M-profiles"). The M-profiles integration is very similar to NBAFM integration explained above except that the integration calculation (see Figure 3-2) is performed on emissions factors instead of on emissions, and a much larger set of pollutants are integrated besides NBAFM. The list of integrated pollutants is described in Table 3-6. An additional run of the Speciation Tool was necessary to create the M-profiles that were then loaded into the MOVES default database. Fourth, for California, the EPA applied adjustment factors to SMOKE-MOVES to produce California adjusted model-ready files. By applying the ratios through SMOKE-MOVES, the CARB inventories are essentially speciated to match EPA estimated speciation. This resulted in changes to the VOC HAPs from what CARB submitted to the EPA.

Table 3-6. MOVES integrated species in M-profiles

MOVES ID	Pollutant Name
5	Methane (CH4)
20	Benzene
21	Ethanol
22	MTBE
24	1,3-Butadiene
25	Formaldehyde
26	Acetaldehyde
27	Acrolein
40	2,2,4-Trimethylpentane
41	Ethyl Benzene
42	Hexane
43	Propionaldehyde
44	Styrene
45	Toluene
46	Xylene
185	Naphthalene gas

[23] Because the EF table has the speciation "baked" into the factors, all counties that are in the county group (i.e., are mapped to that representative county) will have the same speciation.
[24] For more details on the use of model-ready EF, see the SMOKE 3.7 documentation: https://www.cmascenter.org/smoke/documentation/3.7/html/.

For the nonroad sector, all sources are integrated using the same list of integrated pollutants as shown in Table 3-6. The integration calculations are performed within MOVES. For California and Texas, all VOC HAPs were recalculated using MOVES HAP/VOC ratios based on the MOVES run so that VOC speciation methodology would be consistent across the country. NONHAPTOG emissions by speciation profile were also calculated based on MOVES data in California in Texas.

For nonroad emissions in California and Texas, where state-provided emissions were used, MOVES-style speciation has been implemented in 2016v2 and carried into 2016v3, with NONHAPTOG and PM2.5 pre-split by profiles and with all the HAPs needed for VOC speciation augmented based on MOVES data in CA and TX. This means in 2016v2 and 2016v3, onroad emissions in California and Texas are speciated consistently with the rest of the country, while in 2016v1 they were speciated using older speciation profiles.

MOVES-MEXICO for onroad used the same speciation approach as for the U.S. in that the larger list of species shown in Table 3-6 was used. However, MOVES-MEXICO used an older version of the CB6 mechanism sometimes referred to as "CB6-CAMx". That mechanism is missing the model species XYLMN and SOAALK and were added post-SMOKE as follows:

- XYLMN = XYL[1]-0.966*NAPHTHALENE[1]
- PAR = PAR[1]-0.00001*NAPHTHALENE[1]
- SOAALK = 0.108*PAR[1]

The CB6R3AE7 mechanism includes other new species which are not part of CB6-CAMx, such as IVOC. CB6R3AE7-specific species were not added to the MOVES-MEXICO emissions because those extra species would be expected to have only a minor impact.

For the beis sector, the speciation profiles used by BEIS are not included in SPECIATE. BEIS4 includes the species (SESQ) that is mapped to the BEIS model species SESQT (Sesquiterpenes). The profile code associated with BEIS4 for use with CB05 is "B10C5," while the profile for use with CB6 is "B10C6." The main difference between the profiles is the explicit treatment of acetone emissions in B10C6. The biogenic speciation files are managed in the CMAQ Github repository [25].

3.2.1.3 Oil and gas related speciation profiles

Several oil and gas profiles were developed or assigned to sources in np_oilgas and pt_oilgas to better reflect region-specific differences in VOC composition and whether the process SCC would include controlled emissions, considering the controls are not part of the SCC. For example, SCC 2310030300 (Gas Well Water Tank Losses) in Colorado are controlled by a 95% efficient flare, so a profile (DJTFLR95) was developed to represent the composition of the VOC exiting the flare. Region-specific profiles were also available for several areas, some of which were included in SPECIATE5.1 and others added to SPECIATE v5.2. These profiles are used in the 2016v3 platform and are listed in Appendix B. Additional documentation is available in the SPECIATE database.

For the profiles in SPECIATE v5.2:

- The Southern Ute profiles (SUIROGCT and SUIROGWT) applied to Archuleta and La Plata counties in southwestern Colorado were developed from data provided in Tables 19 and 20 of the report by Oakley Hayes, Matt Wampler, Danny Powers (December 2019), "Final Report for 2017

[25] https://github.com/USEPA/CMAQ/blob/main/CCTM/src/biog/beis4/gspro_biogenics.txt.

Southern Ute Indian Tribe Comprehensive Emissions Inventory for Criteria Pollutants, Hazardous Air Pollutants, and Greenhouse Gases."[26]

- A composite coal bed methane produced water profile, CBMPWWY, was developed by compositing a subset of the SPECIATE 5.0 pond profiles associated with coal bed methane wells. The SPECIATE 5.0 pond profiles were developed based on the publication: "Lyman, Seth N, Marc L Mansfield, Huy NQ Tran, Jordan D Evans, Colleen Jones, Trevor O'Neil, Ric Bowers, Ann Smith, and Cara Keslar. 2018. 'Emissions of Organic Compounds from Produced Water Ponds I: Characteristics and Speciation', Science of the Total Environment, 619: 896-905[27]." Note that the pond profiles from this publication are included in SPECIATE 5.0; but a composite to represent coal bed methane wells had not been developed for SPECIATE 5.0 and this new profile is in SPECIATE 5.2.
- The DJTFLR95 profile, DJ Condensate Flare Profile with DRE 95%, filled a need for the flared condensate and produced water tanks for Colorado's oil and gas operations. This profile was developed using the same approach as was used for the FLR99 (and other FLR**) SPECIATE 4.5 profiles, but instead of using profile 8949 for the uncombusted gas, it uses the Denver-Julesburg Basin Condensate composite (95398) and it quantifies the combustion by-products based on a 95% DRE. The approach for combining profile 95398 with combustion by-products based on the TCEQ's flare study (Allen, David T, and Vincent M Torres, University of Texas, Austin. 2011. 'TCEQ 2010 Flare Study Final Report', Texas Commission on Environmental Quality[28]) is the same as used in the workbook for the FLR** SPECIATE4.5 profiles and can be found in the flr99 zip file referenced in the SPECIATE database. The approach uses the analysis developed by Ramboll (Ramboll and EPA, 2017).

In addition to region-specific assignments, multiple profiles were assigned to select county/SCC combinations using the SMOKE feature discussed in 3.2.1.1. Oil and gas SCCs for associated gas, condensate tanks, crude oil tanks, dehydrators, liquids unloading and well completions represent the total VOC from the process, including the portions of process that may be flared or directed to a reboiler. For example, SCC 2310021400 (gas well dehydrators) consists of process, reboiler, and/or flaring emissions. There are not separate SCCs for the flared portion of the process or the reboiler. However, the VOC associated with these three portions can have very different speciation profiles. Therefore, it is necessary to have an estimate of the amount of VOC from each of the portions (process, flare, reboiler) so that the appropriate speciation profiles can be applied to each portion. The Nonpoint Oil and Gas Emission Estimation Tool generates an intermediate file which provides flare, non-flare (process), and reboiler (for dehydrators) emissions for six source categories that have flare emissions: by county FIPS and SCC code for the U.S. From these emissions the fraction of the emissions to assign to each profile was computed and incorporated into the 2016v2 and v3 platforms. These fractions can vary by county FIPS, because they depend on the level of controls, which is an input to the Speciation Tool.

---

[26] https://www.southernute-nsn.gov/wp-content/uploads/sites/15/2019/12/191203-SUIT-CY2017-Emissions-Inventory-Report-FINAL.pdf.
[27] http://doi.org/10.1016/j.scitotenv.2017.11.161.
[28] https://downloads.regulations.gov/EPA-HQ-OAR-2012-0133-0047/attachment_32.pdf

Table 3-7. Basin/Region-specific profiles for oil and gas

Profile Code	Description	Region (if not in profile name)
DJVNT_R	Denver-Julesburg Basin Produced Gas Composition from Non-CBM Gas Wells	
PNC01_R	Piceance Basin Produced Gas Composition from Non-CBM Gas Wells	
PNC02_R	Piceance Basin Produced Gas Composition from Oil Wells	
PNC03_R	Piceance Basin Flash Gas Composition for Condensate Tank	
PNCDH	Piceance Basin, Glycol Dehydrator	
PRBCB_R	Powder River Basin Produced Gas Composition from CBM Wells	
PRBCO_R	Powder River Basin Produced Gas Composition from Non-CBM Wells	
PRM01_R	Permian Basin Produced Gas Composition for Non-CBM Wells	
SSJCB_R	South San Juan Basin Produced Gas Composition from CBM Wells	
SSJCO_R	South San Juan Basin Produced Gas Composition from Non-CBM Gas Wells	
SWFLA_R	SW Wyoming Basin Flash Gas Composition for Condensate Tanks	
SWVNT_R	SW Wyoming Basin Produced Gas Composition from Non-CBM Wells	
UNT01_R	Uinta Basin Produced Gas Composition from CBM Wells	
WRBCO_R	Wind River Basin Produced Gagres Composition from Non-CBM Gas Wells	
95087a	Oil and Gas - Composite - Oil Field - Oil Tank Battery Vent Gas	East Texas
95109a	Oil and Gas - Composite - Oil Field - Condensate Tank Battery Vent Gas	East Texas
95417	Uinta Basin, Untreated Natural Gas	
95418	Uinta Basin, Condensate Tank Natural Gas	
95419	Uinta Basin, Oil Tank Natural Gas	
95420	Uinta Basin, Glycol Dehydrator	
95398	Composite Profile - Oil and Natural Gas Production - Condensate Tanks	Denver-Julesburg
95399	Composite Profile - Oil Field – Wells	California
95400	Composite Profile - Oil Field – Tanks	California
95403	Composite Profile - Gas Wells	San Joaquin
UTUBOGC	Raw Gas from Oil Wells - Composite Uinta basin	
UTUBOGD	Raw Gas from Gas Wells - Composite Uinta basin	
UTUBOGE	Flash Gas from Oil Tanks - including Carbonyls - Composite Uinta basin	
UTUBOGF	Flash Gas from Condensate Tanks - including Carbonyls - Composite Uinta basin	
PAGAS01	Oil and Gas-Produced Gas Composition from Gas Wells-Greene Co, PA	
PAGAS02	Oil and Gas-Produced Gas Composition from Gas Wells-Butler Co, PA	
PAGAS03	Oil and Gas-Produced Gas Composition from Gas Wells-Washington Co, PA	
SUIROGCT	Flash Gas from Condensate Tanks - Composite Southern Ute Indian Reservation	
CMU01	Oil and Gas - Produced Gas Composition from Gas Wells - Central Montana Uplift – Montana	
WIL01	Oil and Gas - Flash Gas Composition from Tanks at Oil Wells - Williston Basin North Dakota	

Profile Code	Description	Region (if not in profile name)
WIL02	Oil and Gas - Flash Gas Composition from Tanks at Oil Wells - Williston Basin Montana	
WIL03	Oil and Gas - Produced Gas Composition from Oil Wells - Williston Basin North Dakota	
WIL04	Oil and Gas - Produced Gas Composition from Oil Wells - Williston Basin Montana	

3.2.1.4 Mobile source related VOC speciation profiles

The VOC speciation approach for mobile source and mobile source-related source categories is customized to account for the impact of fuels and engine type and technologies. The impact of fuels also affects the parts of the nonpt and ptnonipm sectors that are related to mobile sources such as portable fuel containers and gasoline distribution.

The VOC speciation profiles for the nonroad sector other than for California are listed in Table 3-8. They include new profiles (i.e., those that begin with "953") for 2-stroke and 4-stroke gasoline engines running on E0 and E10 and compression ignition engines with different technologies developed from recent EPA test programs, which also supported the updated toxics emission factor in MOVES2014a (Reichle, 2015 and EPA, 2015b).

Table 3-8. TOG MOVES-SMOKE Speciation for nonroad emissions used for the 2016 Platform

Profile	Profile Description	Engine Type	Engine Technology	Engine Size	Horse-power category	Fuel	Fuel Sub-type	Emission Process
95327	SI 2-stroke E0	SI 2-stroke	all	All	All	Gasoline	E0	exhaust
95328	SI 2-stroke E10	SI 2-stroke	all	All	All	Gasoline	E10	exhaust
95329	SI 4-stroke E0	SI 4-stroke	all	All	All	Gasoline	E0	exhaust
95330	SI 4-stroke E10	SI 4-stroke	all	All	All	Gasoline	E10	exhaust
95331	CI Pre-Tier 1	CI	Pre-Tier 1	All	All	Diesel	All	exhaust
95332	CI Tier 1	CI	Tier 1	All	All	Diesel	All	exhaust
95333	CI Tier 2	CI	Tier 2 and 3	all	All	Diesel	All	exhaust
95333a[29]	CI Tier 2	CI	Tier 4	<56 kW (75 hp)	S	Diesel	All	exhaust
8775	ACES Phase 1 Diesel Onroad	CI Tier 4	Tier 4	>=56 kW (75 hp)	L	Diesel	All	exhaust
8753	E0 Evap	SI	all	all	All	Gasoline	E0	evaporative
8754	E10 Evap	SI	all	all	All	Gasoline	E10	evaporative
8766	E0 evap permeation	SI	all	all	All	Gasoline	E0	permeation
8769	E10 evap permeation	SI	all	all	All	Gasoline	E10	permeation
8869	E0 Headspace	SI	all	all	All	Gasoline	E0	headspace
8870	E10 Headspace	SI	all	all	All	Gasoline	E10	headspace

[29] 95333a replaced 95333. This correction was made to remove alcohols due to suspected contamination. Additional information is available in SPECIATE.

Profile	Profile Description	Engine Type	Engine Technology	Engine Size	Horse-power category	Fuel	Fuel Sub-type	Emission Process
1001	CNG Exhaust	All	all	all	All	CNG	All	exhaust
8860	LPG exhaust	All	all	all	All	LPG	All	exhaust

Speciation profiles for VOC in the nonroad sector account for the ethanol content of fuels across years. A description of the actual fuel formulations can be found in the NEI TSD. For previous platforms, the EPA used “COMBO” profiles to model combinations of profiles for E0 and E10 fuel use, but beginning with 2014v7.0 platform, the appropriate allocation of E0 and E10 fuels is done by MOVES.

Combination profiles reflecting a combination of E10 and E0 fuel use ideally would be used for sources upstream of mobile sources such as portable fuel containers (PFCs) and other fuel distribution operations associated with the transfer of fuel from bulk terminals to pumps (BTP), which are in the nonpt sector. For these sources, ethanol may be mixed into the fuels, in which case speciation would change across years. The speciation changes from fuels in the ptnonipm sector include BTP distribution operations inventoried as point sources. Refinery-to-bulk terminal (RBT) fuel distribution and bulk plant storage (BPS) speciation does not change across the modeling cases because this is considered upstream from the introduction of ethanol into the fuel. The mapping of fuel distribution SCCs to PFC, BTP, BPS, and RBT emissions categories can be found in Appendix C. In 2016v3 platform, all of these sources get E10 speciation.

Table 3-9 summarizes the different profiles utilized for the fuel-related sources in each of the sectors for 2016. The term “COMBO” indicates that a combination of the profiles listed was used to speciate that subcategory using the GSPRO_COMBO file.

Table 3-9. Select mobile-related VOC profiles 2016

Sector	Sub-category	Profile	
Nonroad non-US	gasoline exhaust	COMBO	
		8750a	Pre-Tier 2 E0 exhaust
		8751a	Pre-Tier 2 E10 exhaust
nonpt/ ptnonipm	PFC and BTP	COMBO	
		8869	E0 Headspace
		8870	E10 Headspace
nonpt/ ptnonipm	Bulk plant storage (BPS) and refine-to-bulk terminal (RBT) sources	8870	E10 Headspace

The speciation of onroad VOC occurs completely within MOVES. MOVES accounts for fuel type and properties, emission standards as they affect different vehicle types and model years, and specific emission processes. Table 3-10 describes the M-profiles available to MOVES depending on the model year range, MOVES process (processID), fuel sub-type (fuelSubTypeID), and regulatory class (regClassID). m While MOVES maps the liquid diesel profile to several processes, MOVES only estimates emissions from refueling spillage loss (processID 19). The other evaporative and refueling processes from diesel vehicles have zero emissions.

Table 3-11 through Table 3-13 describe the meaning of these MOVES codes. For a specific representative county and analytic year, there will be a different mix of these profiles. For example, for HD diesel exhaust, the emissions will use a combination of profiles 8774M and 8775M depending on the proportion of HD vehicles that are pre-2007 model years (MY) in that particular county. As that county is projected farther into the future, the proportion of pre-2007 MY vehicles will decrease. A second example, for gasoline exhaust (not including E-85), the emissions will use a combination of profiles 8756M, 8757M, 8758M, 8750aM, and 8751aM. Each representative county has a different mix of these key properties and, therefore, has a unique combination of the specific M-profiles. More detailed information on how MOVES speciates VOC and the profiles used is provided in the technical document, "Speciation of Total Organic Gas and Particulate Matter Emissions from On-road Vehicles in MOVES2014" (EPA, 2015c).

Table 3-10. Onroad M-profiles

Profile	Profile Description	Model Years	ProcessID	FuelSubTypeID	RegClassID
1001M	CNG Exhaust	1940-2050	1,2,15,16	30	48
4547M	Diesel Headspace	1940-2050	11	20,21,22	0
4547M	Diesel Headspace	1940-2050	12,13,18,19	20,21,22	10,20,30,40,41, 42,46,47,48
8753M	E0 Evap	1940-2050	12,13,19	10	10,20,30,40,41,42, 46,47,48
8754M	E10 Evap	1940-2050	12,13,19	12,13,14	10,20,30,40,41, 42,46,47,48
8756M	Tier 2 E0 Exhaust	2001-2050	1,2,15,16	10	20,30
8757M	Tier 2 E10 Exhaust	2001-2050	1,2,15,16	12,13,14	20,30
8758M	Tier 2 E15 Exhaust	1940-2050	1,2,15,16	15,18	10,20,30,40,41, 42,46,47,48
8766M	E0 evap permeation	1940-2050	11	10	0
8769M	E10 evap permeation	1940-2050	11	12,13,14	0
8770M	E15 evap permeation	1940-2050	11	15,18	0
8774M	Pre-2007 MY HDD exhaust	1940-2006	1,2,15,16,17,90	20, 21, 22	40,41,42,46,47, 48
8774M	Pre-2007 MY HDD exhaust	1940-2050	91[30]	20, 21, 22	46,47
8774M	Pre-2007 MY HDD exhaust	1940-2006	1,2,15,16	20, 21, 22	20,30
8775M	2007+ MY HDD exhaust	2007-2050	1,2,15,16	20, 21, 22	20,30
8775M	2007+ MY HDD exhaust	2007-2050	1,2,15,16,17,90	20, 21, 22	40,41,42,46,47,48
8855M	Tier 2 E85 Exhaust	1940-2050	1,2,15,16	50, 51, 52	10,20,30,40,41, 42,46,47,48
8869M	E0 Headspace	1940-2050	18	10	10,20,30,40,41, 42,46,47,48
8870M	E10 Headspace	1940-2050	18	12,13,14	10,20,30,40,41, 42,46,47,48

[30] 91 is the processed for APUs which are diesel engines not covered by the 2007 Heavy-Duty Rule, so the older technology applies to all years.

Profile	Profile Description	Model Years	ProcessID	FuelSubTypeID	RegClassID
8871M	E15 Headspace	1940-2050	18	15,18	10,20,30,40,41, 42,46,47,48
8872M	E15 Evap	1940-2050	12,13,19	15,18	10,20,30,40,41, 42,46,47,48
8934M	E85 Evap	1940-2050	11	50,51,52	0
8934M	E85 Evap	1940-2050	12,13,18,19	50,51,52	10,20,30,40,41, 42,46,47,48
8750aM	Pre-Tier 2 E0 exhaust	1940-2000	1,2,15,16	10	20,30
8750aM	Pre-Tier 2 E0 exhaust	1940-2050	1,2,15,16	10	10,40,41,42,46,47,48
8751aM	Pre-Tier 2 E10 exhaust	1940-2000	1,2,15,16	11,12,13,14	20,30
8751aM	Pre-Tier 2 E10 exhaust	1940-2050	1,2,15,16	11,12,13,14,15, 18[31]	10,40,41,42,46,47,48
95120[m]	Liquid Diesel	19602060	11	20,21,22	0
95120[m]	Liquid Diesel	19602060	12,13,18,19	20,21,22	10,20,30,40,41,42,46,47,4 8
95335a	2010+ MY HDD exhaust	20102060	1,2,15,16,17,90	20,21,22	40,41,42,46,47,48

[m] While MOVES maps the liquid diesel profile to several processes, MOVES only estimates emissions from refueling spillage loss (processID 19). The other evaporative and refueling processes from diesel vehicles have zero emissions.

Table 3-11. MOVES process IDs

Process ID	Process Name
1	Running Exhaust*
2	Start Exhaust
9	Brakewear
10	Tirewear
11	Evap Permeation
12	Evap Fuel Vapor Venting
13	Evap Fuel Leaks
15	Crankcase Running Exhaust*
16	Crankcase Start Exhaust
17	Crankcase Extended Idle Exhaust
18	Refueling Displacement Vapor Loss
19	Refueling Spillage Loss
20	Evap Tank Permeation
21	Evap Hose Permeation
22	Evap RecMar Neck Hose Permeation
23	Evap RecMar Supply/Ret Hose Permeation
24	Evap RecMar Vent Hose Permeation
30	Diurnal Fuel Vapor Venting

[31] The profile assignments for pre-2001 gasoline vehicles fueled on E15/E20 fuels (subtypes 15 and 18) were corrected for MOVES2014a. This model year range, process, fuelsubtype regclass combination is already assigned to profile 8758.

31	HotSoak Fuel Vapor Venting
32	RunningLoss Fuel Vapor Venting
40	Nonroad
90	Extended Idle Exhaust
91	Auxiliary Power Exhaust

**** Off-network idling is a process in MOVES3 that is part of processes 1 and 15 but assigned to road type 1 (off-network) instead of types 2-5***

Table 3-12. MOVES Fuel subtype IDs

Fuel Subtype ID	Fuel Subtype Descriptions
10	Conventional Gasoline
11	Reformulated Gasoline (RFG)
12	Gasohol (E10)
13	Gasohol (E8)
14	Gasohol (E5)
15	Gasohol (E15)
18	Ethanol (E20)
20	Conventional Diesel Fuel
21	Biodiesel (BD20)
22	Fischer-Tropsch Diesel (FTD100)
30	Compressed Natural Gas (CNG)
50	Ethanol
51	Ethanol (E85)
52	Ethanol (E70)

Table 3-13. MOVES regclass IDs

Reg. Class ID	Regulatory Class Description
0	Doesn't Matter
10	Motorcycles
20	Light Duty Vehicles
30	Light Duty Trucks
40	Class 2b Trucks with 2 Axles and 4 Tires (8,500 lbs < GVWR <= 10,000 lbs)
41	Class 2b Trucks with 2 Axles and at least 6 Tires or Class 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs)
42	Class 4 and 5 Trucks (14,000 lbs < GVWR <= 19,500 lbs)
46	Class 6 and 7 Trucks (19,500 lbs < GVWR <= 33,000 lbs)
47	Class 8a and 8b Trucks (GVWR > 33,000 lbs)
48	Urban Bus (see CFR Sec 86.091_2)

For portable fuel containers (PFCs) and fuel distribution operations associated with the bulk-plant-to-pump (BTP) distribution, a 10% ethanol mix (E10) was assumed for speciation purposes. Refinery to bulk terminal (RBT) fuel distribution and bulk plant storage (BPS) speciation are considered upstream from the introduction of ethanol into the fuel; therefore, a single profile is sufficient for these sources. No refined information on potential VOC speciation differences between cellulosic diesel and cellulosic ethanol sources was available; therefore, cellulosic diesel and cellulosic ethanol sources used the same SCC (30125010: Industrial Chemical Manufacturing, Ethanol by Fermentation production) for VOC speciation as was used for corn ethanol plants.

3.2.2 PM speciation

In addition to VOC profiles, the SPECIATE database also contains profiles for speciating $PM_{2.5}$. $PM_{2.5}$ was speciated into the AE6 species associated with CMAQ 5.0.1 and later versions. Most of the PM profiles come from the 911XX series (Reff et. al, 2009), which include updated AE6 speciation.[32] Starting with the 2014v7.1 platform, profile 91112 (Natural Gas Combustion – Composite) was replaced with 95475 (Composite -Refinery Fuel Gas and Natural Gas Combustion). This updated profile is an AE6-ready profile based on the median of 3 SPECIATE4.5 profiles from which AE6 versions were made and the resulting profile added to SPECIATE5.0: boilers (95125a), process heaters (95126a) and internal combustion combined cycle/cogen plant exhaust (95127a). As with profile 91112, these profiles are based on tests using natural gas and refinery fuel gas (England et al., 2007). Profile 91112 which is also based on refinery gas and natural gas is thought to overestimate EC.

Profile 95475 (Composite -Refinery Fuel Gas and Natural Gas Combustion) is shown along with the underlying profiles composited in Figure 3-3. Figure 3-4 shows a comparison of the new profile as of the 2014v7.1 platform with the one that we had been using in the 2014v7.0 and earlier platforms.

The newest PM profile for the 2016v2 platform that is also included in the 2016v3 platform is the Sugar Cane Pre-Harvest Burning Mexico profile (SUGP02). This profile falls under the sector ptagfire and are included in SPECIATE 5.2.

Additionally, a series of regional fire profiles were added to SPECIATE 5.1 and used in 2016v2 and 2016v3. These fall under the sector ptfire and are as shown in Table 3-14.

Table 3-14. Regional Fire Profiles

Sector	Pollutant	Profile Code	Profile Description
Ptfire	PM	95793	Forest Fire-Flaming-Oregon AE6
Ptfire	PM	95794	Forest Fire-Smoldering-Oregon AE6
Ptfire	PM	95798	Forest Fire-Flaming-North Carolina AE6
Ptfire	PM	95799	Forest Fire-Smoldering-North Carolina AE6
Ptfire	PM	95804	Forest Fire-Flaming-Montana AE6
Ptfire	PM	95805	Forest Fire-Smoldering-Montana AE6
Ptfire	PM	95807	Forest Fire Understory-Flaming-Minnesota AE6
Ptfire	PM	95808	Forest Fire Understory-Smoldering-Minnesota AE6
Ptfire	PM	95809	Grass Fire-Field-Kansas AE6

[32] The exceptions are 5675AE6 (Marine Vessel – Marine Engine – Heavy Fuel Oil) used for cmv_c3 and 92018 (Draft Cigarette Smoke – Simplified) used in nonpt. 5675AE6 is an update of profile 5675 to support AE6 PM speciation.

Figure 3-3. Profiles composited for PM gas combustion related sources

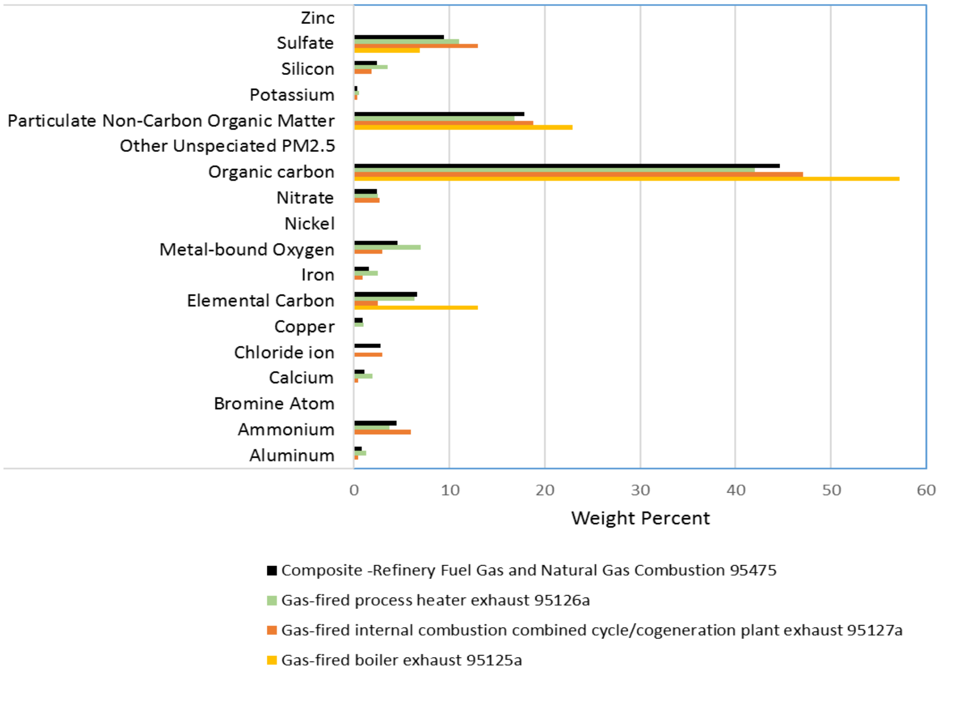
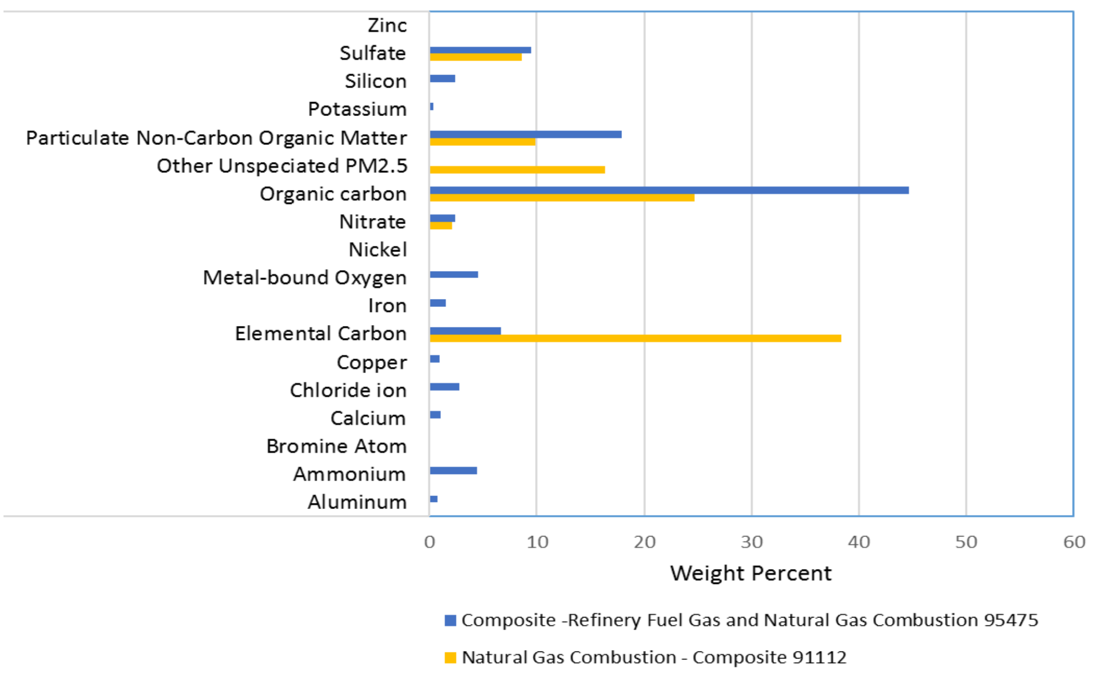


Figure 3-4. Comparison of PM profiles used for Natural gas combustion related sources



3.2.2.1 Mobile source related PM2.5 speciation profiles

For the onroad sector, for all processes except brake and tire wear, PM speciation occurs within MOVES itself, not within SMOKE (similar to the VOC speciation described above). The advantage of using MOVES to speciate PM is that during the internal calculation of MOVES, the model has complete information on the characteristics of the fleet and fuels (e.g., model year, sulfur content, process, etc.) to accurately match to specific profiles. This means that MOVES produces EF tables that include total PM (e.g., PM_{10} and $PM_{2.5}$) and speciated PM (e.g., PEC, PFE). SMOKE essentially calculates the PM components by using the appropriate EF without further speciation.[33] The specific profiles used within MOVES include two CNG profiles, 45219 and 45220, which were added to SPECIATE4.5. A list of profiles is provided in the technical document, "Speciation of Total Organic Gas and Particulate Matter Emissions from On-road Vehicles in MOVES2014" (EPA, 2015c). No changes to the mobile source PM speciation profiles were made in the 2016v3 platform.

For onroad brake and tire wear, the PM is speciated in the *moves2smk* postprocessor that prepares the emission factors for processing in SMOKE. The formulas for this are based on the standard speciation factors from brake and tire wear profiles, which were updated from the v6.3 platform based on data from a Health Effects Institute report (Schauer, 2006). Table 3-15 shows the differences in the v7.1 (alpha) and 2011v6.3 profiles.

Table 3-15. Brake and tire PM2.5 profiles compared to those used in the 2011v6.3 Platform

Inventory Pollutant	Model Species	V6.3 platform brakewear profile: 91134	SPECIATE4.5 brakewear profile: 95462 from Schauer (2006)	V6.3 platform tirewear profile: 91150	SPECIATE4.5 tirewear profile: 95460 from Schauer (2006)
PM2_5	PAL	0.00124	0.000793208	6.05E-04	3.32401E-05
PM2_5	PCA	0.01	0.001692177	0.00112	
PM2_5	PCL	0.001475		0.0078	
PM2_5	PEC	0.0261	0.012797085	0.22	0.003585907
PM2_5	PFE	0.115	0.213901692	0.0046	0.00024779
PM2_5	PH2O	0.0080232		0.007506	
PM2_5	PK	1.90E-04	0.000687447	3.80E-04	4.33129E-05
PM2_5	PMG	0.1105	0.002961309	3.75E-04	0.000018131
PM2_5	PMN	0.001065	0.001373836	1.00E-04	1.41E-06
PM2_5	PMOTHR	0.4498	0.691704999	0.0625	0.100663209
PM2_5	PNA	1.60E-04	0.002749787	6.10E-04	7.35312E-05
PM2_5	PNCOM	0.0428	0.020115749	0.1886	0.255808124
PM2_5	PNH4	3.00E-05		1.90E-04	
PM2_5	PNO3	0.0016		0.0015	
PM2_5	POC	0.107	0.050289372	0.4715	0.639520309
PM2_5	PSI	0.088		0.00115	
PM2_5	PSO4	0.0334		0.0311	
PM2_5	PTI	0.0036	0.000933341	3.60E-04	5.04E-06

[33] Unlike previous platforms, the PM components (e.g., POC) are now consistently defined between MOVES2014 and CMAQ. For more details on the use of model-ready EF, see the SMOKE 3.7 documentation: https://www.cmascenter.org/smoke/documentation/3.7/html/.

The formulas used based on brake wear profile 95462 and tire wear profile 95460 are as follows:

```
POC = 0.6395 * PM25TIRE + 0.0503 * PM25BRAKE
PEC = 0.0036 * PM25TIRE + 0.0128 * PM25BRAKE
PNO3 = 0.000 * PM25TIRE + 0.000 * PM25BRAKE
PSO4 = 0.0 * PM25TIRE + 0.0 * PM25BRAKE
PNH4 = 0.000 * PM25TIRE + 0.0000 * PM25BRAKE
PNCOM = 0.2558 * PM25TIRE + 0.0201 * PM25BRAKE
```

For California onroad emissions, adjustment factors were applied to SMOKE-MOVES to produce California adjusted model-ready files. California did not supply speciated PM, therefore, the adjustment factors applied to PM2.5 were also applied to the speciated PM components. By applying the ratios through SMOKE-MOVES, the CARB inventories are essentially speciated to match EPA estimated speciation.

For nonroad PM2.5, speciation is partially done within MOVES such that it does not need to be run for a specific chemical mechanism. For nonroad, MOVES outputs emissions of PM2.5 split by speciation profile. Similar to how VOC and NONHAPTOG are speciated, PM2.5 is now also speciated this way starting with MOVES2014b. For California and Texas, PM2.5 emissions split by speciation profile are estimated from total PM2.5 based on MOVES data in California and Texas, so that PM is speciated consistently across the country. The PM2.5 profiles assigned to nonroad sources are listed in Table 3-16.

Table 3-16. Nonroad PM2.5 profiles

SPECIATE4.5 Profile Code	SPECIATE4.5 Profile Name	Assigned to Nonroad sources based on Fuel Type
8996	Diesel Exhaust - Heavy-heavy duty truck - 2007 model year with NCOM	Diesel
91106	HDDV Exhaust – Composite	Diesel
91113	Nonroad Gasoline Exhaust – Composite	Gasoline
95219	CNG Transit Bus Exhaust	CNG and LPG

3.2.3 NO_X speciation

NOx emission factors and therefore NOx inventories are developed on a NO_2 weight basis. For air quality modeling, NO_X is speciated into NO, NO_2, and/or HONO. For the non-mobile sources, the EPA used a single profile “NHONO” to split NO_X into NO and NO_2.

The importance of HONO chemistry, identification of its presence in ambient air and the measurements of HONO from mobile sources have prompted the inclusion of HONO in NOx speciation for mobile sources. Based on tunnel studies, a HONO to NOx ratio of 0.008 was chosen (Sarwar, 2008). For the mobile sources except for onroad (e.g., nonroad, cmv, rail, othon sectors), and for specific SCCs in othar and ptnonipm, the profile “HONO” is used. Table 3-17 gives the split factor for these two profiles. The onroad sector does not use the “HONO” profile to speciate NO_X. MOVES2014 produces speciated NO, NO_2, and HONO by source, including emission factors for these species in the emission factor tables used by SMOKE-MOVES. Within MOVES, the HONO fraction is a constant 0.008 of NO_X. The NO fraction varies by heavy duty versus light duty, fuel type, and model year.

The NO_2 fraction = 1 – NO – HONO. For more details on the NO_X fractions within MOVES, see EPA report "Use of data from 'Development of Emission Rates for the MOVES Model,' Sierra Research, March 3, 2010" available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100F1A5.pdf.

Table 3-17. NO_X speciation profiles

Profile	pollutant	species	split factor
HONO	NOX	NO2	0.092
HONO	NOX	NO	0.9
HONO	NOX	HONO	0.008
NHONO	NOX	NO2	0.1
NHONO	NOX	NO	0.9

3.2.4 Creation of Sulfuric Acid Vapor (SULF)

Since at least the 2002 Platform, sulfuric acid vapor (SULF) has been estimated through the SMOKE speciation process for coal combustion and residual and distillate oil fuel combustion sources. Profiles that compute SULF from SO_2 are assigned to coal and oil combustion SCCs in the GSREF ancillary file. The profiles were derived from information from AP-42 (EPA, 1998), which identifies the fractions of sulfur emitted as sulfate and SO_2 and relates the sulfate as a function of SO2.

Sulfate is computed from SO_2 assuming that gaseous sulfate, which is comprised of many components, is primarily H_2SO_4. The equation for calculating H_2SO_4 is given below.

$$Emissions\ of\ SULF\ (as\ \mathrm{H_2SO_4}) = SO_2\ emissions\ \times \frac{fraction\ of\ S\ emitted\ as\ sulfate}{fraction\ of\ S\ emitted\ as\ SO_2} \times \frac{MW\ H_2SO_4}{MW\ SO_2}$$ Equation 3-1

In the above, *MW* is the molecular weight of the compound. The molecular weights of H_2SO_4 and SO_2 are 98 g/mol and 64 g/mol, respectively.

This method does not reduce SO_2 emissions; it solely adds gaseous sulfate emissions as a function of SO2 emissions. The derivation of the profiles is provided in Table 3-18; a summary of the profiles is provided in Table 3-19.

Table 3-18. Sulfate split factor computation

fuel	SCCs	Profile Code	Fraction as SO2	Fraction as sulfate	Split factor (mass fraction)
Bituminous	1-0X-002-YY, where X is 1, 2 or 3 and YY is 01 thru 19 and 21-ZZ-002-000 where ZZ is 02,03 or 04	95014	0.95	0.014	.014/.95 * 98/64 = 0.0226
Subbituminous	1-0X-002-YY, where X is 1, 2 or 3 and YY is 21 thru 38	87514	.875	0.014	.014/.875 * 98/64 = 0.0245

fuel	SCCs	Profile Code	Fraction as SO2	Fraction as sulfate	Split factor (mass fraction)
Lignite	1-0X-003-YY, where X is 1, 2 or 3 and YY is 01 thru 18 and 21-ZZ-002-000 where ZZ is 02,03 or 04	75014	0.75	0.014	.014/.75 * 98/64 = 0.0286
Residual oil	1-0X-004-YY, where X is 1, 2 or 3 and YY is 01 thru 06 and 21-ZZ-005-000 where ZZ is 02,03 or 04	99010	0.99	0.01	.01/.99 * 98/64 = 0.0155
Distillate oil	1-0X-005-YY, where X is 1, 2 or 3 and YY is 01 thru 06 and 21-ZZ-004-000 where ZZ is 02,03 or 04	99010	0.99	0.01	Same as residual oil

Table 3-19. SO_2 speciation profiles

Profile	pollutant	species	split factor
95014	SO2	SULF	0.0226
95014	SO2	SO2	1
87514	SO2	SULF	0.0245
87514	SO2	SO2	1
75014	SO2	SULF	0.0286
75014	SO2	SO2	1
99010	SO2	SULF	0.0155
99010	SO2	SO2	1

3.3 Temporal Allocation

Temporal allocation is the process of distributing aggregated emissions to a finer temporal resolution, thereby converting annual emissions to hourly emissions as is required by CMAQ. While the total emissions are important, the timing of the occurrence of emissions is also essential for accurately simulating ozone, PM, and other pollutant concentrations in the atmosphere. Many emissions inventories are annual or monthly in nature. Temporal allocation takes these aggregated emissions and distributes the emissions to the hours of each day. This process is typically done by applying temporal profiles to the inventories in this order: monthly, day of the week, and diurnal, with monthly and day-of-week profiles applied only if the inventory is not already at that level of detail.

For 2016v3, temporal profile assignments to SCCs were updated for solvents and for some point and nonpoint SCCs. The new profiles for solvents only impacted the diurnal profiles and are based on Gkatzelis et al. (2021).

The temporal factors applied to the inventory are selected using some combination of country, state, county, SCC, and pollutant. Table 3-20 summarizes the temporal aspects of emissions modeling by comparing the key approaches used for temporal processing across the sectors. In the table, “Daily temporal approach” refers to the temporal approach for getting daily emissions from the inventory using the SMOKE Temporal program. The values given are the values of the SMOKE L_TYPE setting. The “Merge processing approach” refers to the days used to represent other days in the month for the merge step. If this is not “all,” then the SMOKE merge step runs only for representative days, which could include holidays as indicated by the right-most column. The values given are those used for the SMOKE M_TYPE setting (see below for more information).

Table 3-20. Temporal settings used for the platform sectors in SMOKE

Platform sector short name	Inventory resolutions	Monthly profiles used?	Daily temporal approach	Merge processing approach	Process holidays as separate days
afdust_adj	Annual	Yes	week	All	Yes
afdust_ak_adj	Annual	Yes	week	All	Yes
airports	Annual	Yes	week	week	Yes
beis	Hourly	No	n/a	All	No
canada_ag	Monthly	No	mwdss	mwdss	No
canada_og2D	Annual	Yes	mwdss	mwdss	No
cmv_c1c2	Annual	Yes	aveday	aveday	No
cmv_c3	Annual	Yes	aveday	aveday	No
fertilizer	Monthly	No	All	all	No
livestock	Annual	Yes	All	all	No
nonpt	Annual	Yes	week	week	Yes
nonroad	Monthly	No	mwdss	mwdss	Yes
np_oilgas	Annual	Yes	aveday	aveday	No
np_solvents	Annual	Yes	aveday	aveday	No
onroad	Annual & monthly[1]	No	All	all	Yes
onroad_ca_adj	Annual & monthly[1]	No	All	all	Yes
onroad_nonconus	Annual & monthly[1]	No	All	all	Yes
othafdust_adj	Annual	Yes	week	all	No
othar	Annual & monthly	Yes	week	week	No
onroad_can	Monthly	No	week	week	No
onroad_mex	Monthly	No	week	week	No
othpt	Annual & monthly	Yes	mwdss	mwdss	No
othptdust_adj	Monthly	No	week	all	No
pt_oilgas	Annual	Yes	mwdss	mwdss	Yes
ptegu	Annual & hourly	Yes[2]	All	all	No
ptnonipm	Annual	Yes	mwdss	mwdss	Yes
ptagfire	Daily	No	All	all	No
ptfire-rx	Daily	No	All	all	No
ptfire-wild	Daily	No	All	all	No
ptfire_othna	Daily	No	All	all	No
rail	Annual	Yes	aveday	aveday	No
rwc	Annual	No[3]	met-based[3]	All	No[3]

[1]Note the annual and monthly "inventory" actually refers to the activity data (VMT, hoteling, and VPOP) for onroad. VMT and hoteling is monthly and VPOP is annual. The actual emissions are computed on an hourly basis.
[2]Only units that do not have matching hourly CEMS data use monthly temporal profiles.
[3]Except for 2 SCCs that do not use met-based speciation

The following values are used in the table. The value "all" means that hourly emissions are computed for every day of the year and that emissions potentially have day-of-year variation. The value "week" means that hourly emissions computed for all days in one "representative" week, representing all weeks for each month. This means emissions have day-of-week variation, but not week-to-week variation within the month. The value "mwdss" means hourly emissions for one representative Monday, representative weekday (Tuesday through Friday), representative Saturday, and representative Sunday for each month. This means emissions have variation between Mondays, other weekdays, Saturdays and Sundays within the month, but not week-to-week variation within the month. The value "aveday" means hourly emissions computed for one representative day of each month, meaning emissions for all days within a month are the same. Special situations with respect to temporal allocation are described in the following subsections.

In addition to the resolution, temporal processing includes a ramp-up period for several days prior to January 1, 2016, which is intended to mitigate the effects of initial condition concentrations. The ramp-up period was 10 days (December 22-31, 2015). For most sectors, emissions from December 2016 (representative days) were used to fill in emissions for the end of December 2015. For biogenic emissions, December 2015 emissions were processed using 2015 meteorology.

3.3.1 Use of FF10 format for finer than annual emissions

The FF10 inventory format for SMOKE provides a consolidated format for monthly, daily, and hourly emissions inventories. With the FF10 format, a single inventory file can contain emissions for all 12 months and the annual emissions in a single record. This helps simplify the management of numerous inventories. Similarly, daily and hourly FF10 inventories contain individual records with data for all days in a month and all hours in a day, respectively.

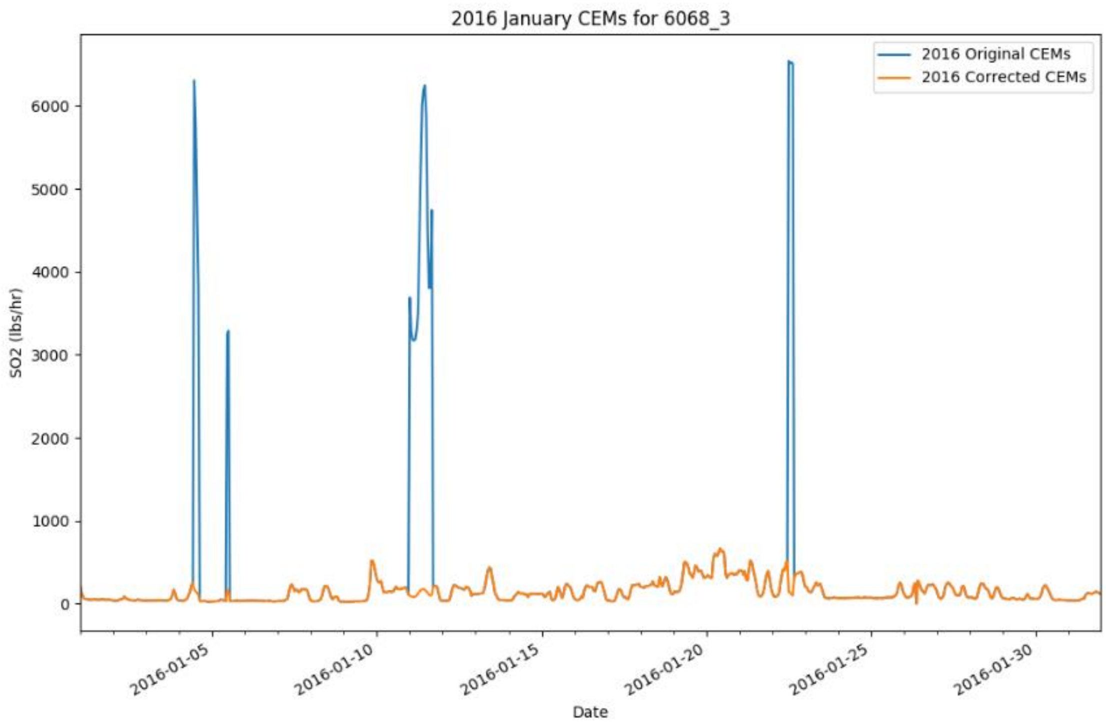
SMOKE prevents the application of temporal profiles on top of the "native" resolution of the inventory. For example, a monthly inventory should not have annual-to-month temporal allocation applied to it; rather, it should only have month-to-day and diurnal temporal allocation. This becomes particularly important when specific sectors have a mix of annual, monthly, daily, and/or hourly inventories. The flags that control temporal allocation for a mixed set of inventories are discussed in the SMOKE documentation. The modeling platform sectors that make use of monthly values in the FF10 files are livestock, nonroad, onroad, onroad_can, onroad_mex, othar, and othpt.

3.3.2 Electric Generating Utility temporal allocation (ptegu)

3.3.2.1 Base year temporal allocation of EGUs

The temporal allocation procedure for EGUs in the base year is differentiated by whether or not the unit could be directly matched to a unit with CEMS data via its ORIS facility code and boiler ID. Note that for units matched to CEMS data, annual totals of their emissions input to CMAQ may be different than the annual values in the 2016 annual inventory because the CEMS data replaces the NO_x and SO_2 annual inventory data for the seasons in which the CEMS are operating. If a CEMS-matched unit is determined to be a partial year reporter, as can happen for sources that run CEMS only in the summer, emissions totaling the difference between the annual emissions and the total CEMS emissions are allocated to the non-summer months. Prior to use of the CEMS data in SMOKE it is processed through the CEMCorrect tool. The CEMCorrect tool identifies hours for which the data were not measured as indicated by the data quality flags in the CEMS data files. Unmeasured data can be filled in with maximum values and thereby cause erroneously high values in the CEMS data. When data were flagged as unmeasured and the values were found to be more than three times the annual mean for that unit, the data for those hours are replaced with annual mean values (Adelman et al., 2012). These adjusted CEMS data were then used for the remainder of the temporal allocation process described below (see Figure 3-5 for an example).

Figure 3-5. Eliminating unmeasured spikes in CEMS data



In modeling platforms prior to 2016 beta, unmatched EGUs were temporally allocated using daily and diurnal profiles weighted by CEMS values within an IPM region, season, and by fuel type (coal, gas, and other). All unit types (peaking and non-peaking) were given the same profile within a region, season and fuel bin. Units identified as municipal waste combustors (MWCs) or cogeneration units (cogens) were given flat daily and diurnal profiles. Beginning with the 2016 beta platform and continuing for the 2016v1, 2016v2,v2, and 2016v3 platforms, the small EGU temporalization process considers peaking units.

The region, fuel, and type (peaking or non-peaking) were identified for each input EGU with CEMS data that are used for generating profiles. The identification of peaking units was based on hourly heat input data from the 2016 base year and the two previous years (2014 and 2015). The heat input was summed for each year. Equation 3-2 shows how the annual heat input value is converted from heat units (BTU/year) to power units (MW) using the unit-level heat rate (BTU/kWh) derived from the NEEDS v6 database. In Equation 3-3 a capacity factor is calculated by dividing the annual unit MW value by the NEEDS v6 unit capacity value (MW) multiplied by the hours in the year. A peaking unit was defined as any unit that had a maximum capacity factor of less than 0.2 for every year (2014, 2015, and 2016) and a 3-year average capacity factor of less than 0.1.

Annual Unit Power Output

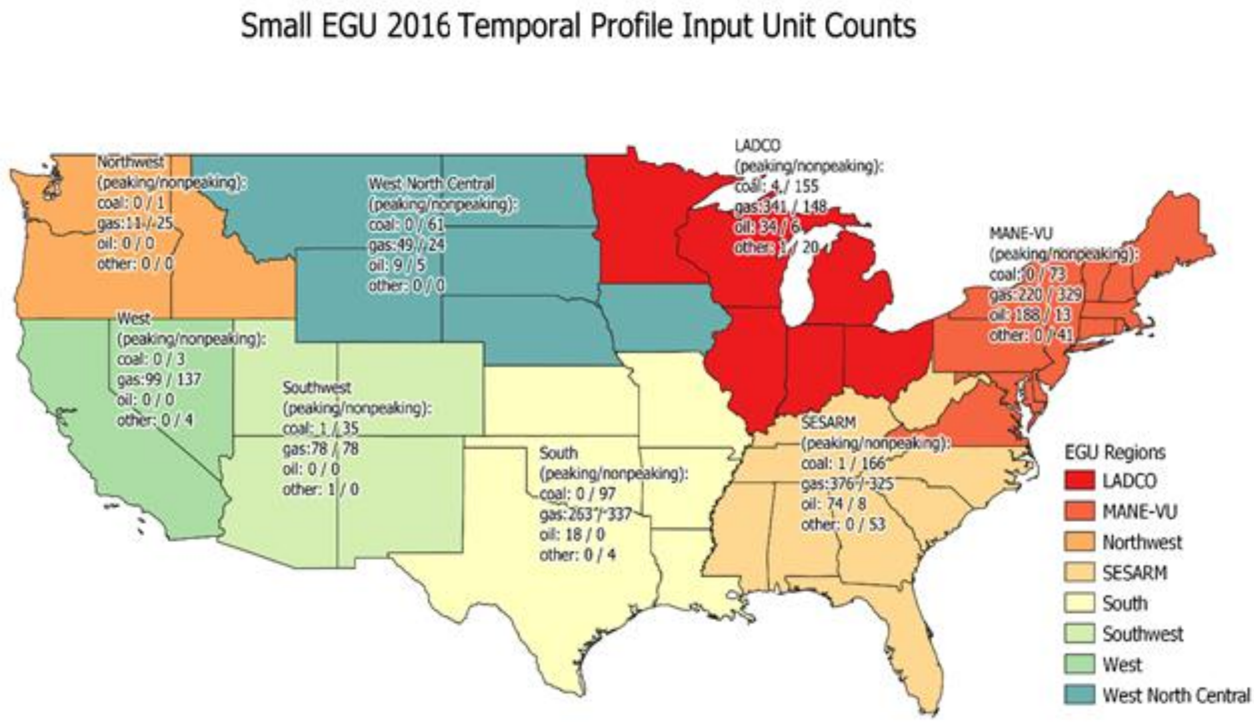
$$nnual\ Unit\ Output\ (MW) = \frac{\sum_{i=0}^{8760} \frac{Hourly\ HI}{(BTU)} * 1000\ \left(\frac{MW}{kW}\right)}{NEEDS\ Heat\ Rate\ \left(\frac{BTU}{kWh}\right)} \qquad \text{Equation 3-2}$$

Unit Capacity Factor

$$nnual\ Unit\ Output\ (MW) = \frac{\sum_{i=0}^{8760} \frac{Hourly\ HI}{(BTU)} * 1000\ \left(\frac{MW}{kW}\right)}{NEEDS\ Heat\ Rate\ \left(\frac{BTU}{kWh}\right)} \qquad \text{Equation 3-3}$$

Input regions were determined from one of the eight EGU modeling regions based on MJO and climate regions. Regions were used to group units with similar climate-based load demands. Region assignment is made on a state level, where all units within a state were assigned to the appropriate region. Unit fuel assignments were made using the primary NEEDS v6 fuel. Units fueled by bituminous, subbituminous, or lignite are assigned to the coal fuel type. Natural gas units were assigned to the gas fuel type. Distillate and residual fuel oil were assigned to the oil fuel type. Units with any other primary fuel were assigned the “other” fuel type. The number of units used to calculate the daily and diurnal EGU temporal profiles are shown in Figure 3-6 by region, fuel, and for peaking/non-peaking. Currently there are 64 unique profiles available based on 8 regions, 4 fuels, and 2 for peaking unit status (peaking and non-peaking).

Figure 3-6. Temporal Profile Input Unit Counts by Fuel and Peaking Unit Classification



The daily and diurnal profiles were calculated for each region, fuel, and peaking type group from the year 2016 CEMS heat input values. The heat input values were summed for each input group to the annual level at each level of temporal resolution: monthly, month-of-day, and diurnal. The sum by temporal resolution value was then divided by the sum of annual heat input in that group to get a set of temporalization factors. Diurnal factors were created for both the summer and winter seasons to account for the variation in hourly load demands between the seasons. For example, the sum of all hour 1 heat input values in the group was divided by the sum of all heat inputs over all hours to get the hour 1 factor. Each grouping contained 12 monthly factors, up to 31 daily factors per month, and two sets of 24 hourly factors. The profiles were weighted by unit size where the units with more heat input have a greater influence on the shape of the profile. Composite profiles were created for each region and type across all fuels as a way to provide profiles for a fuel type that does not have hourly CEMS data in that region. Figure 3-7 shows peaking and non-peaking daily temporal profiles for the gas fuel type in the LADCO region. Figure 3-8 shows the diurnal profiles for the coal fuel type in the Mid-Atlantic Northeast Visibility Union (MANE-VU) region.

Figure 3-7. Example Daily Temporal Profiles for the LADCO Region and the Gas Fuel Type

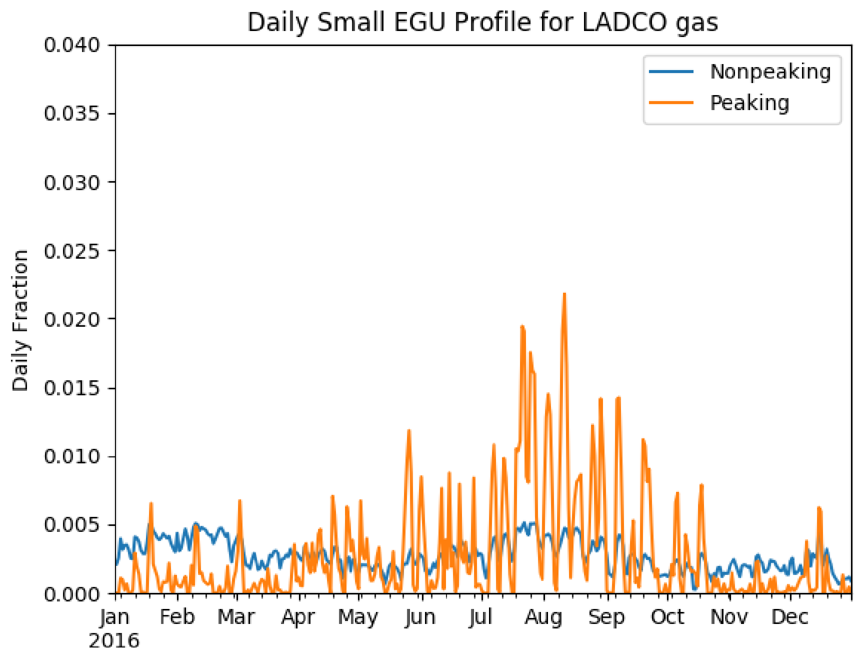
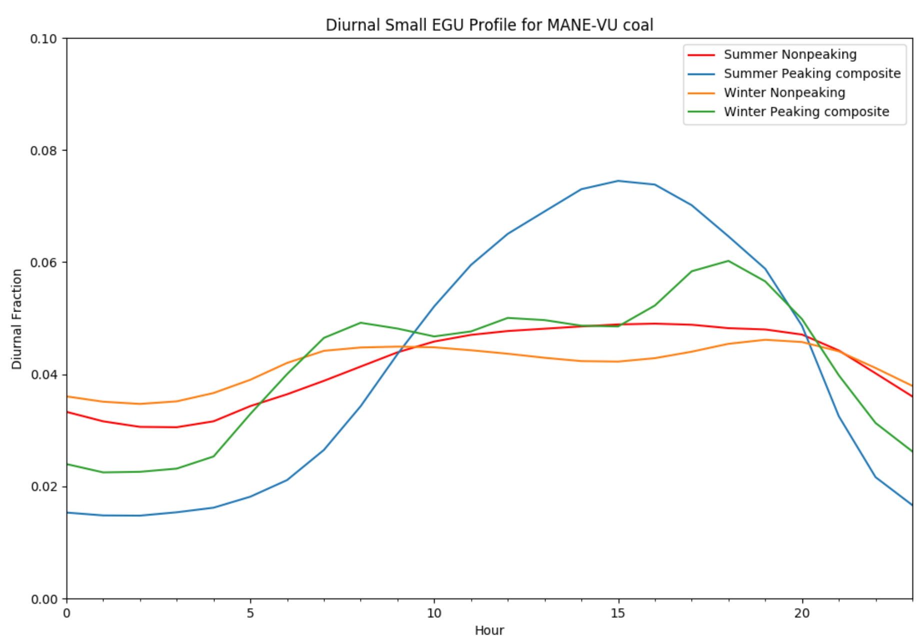
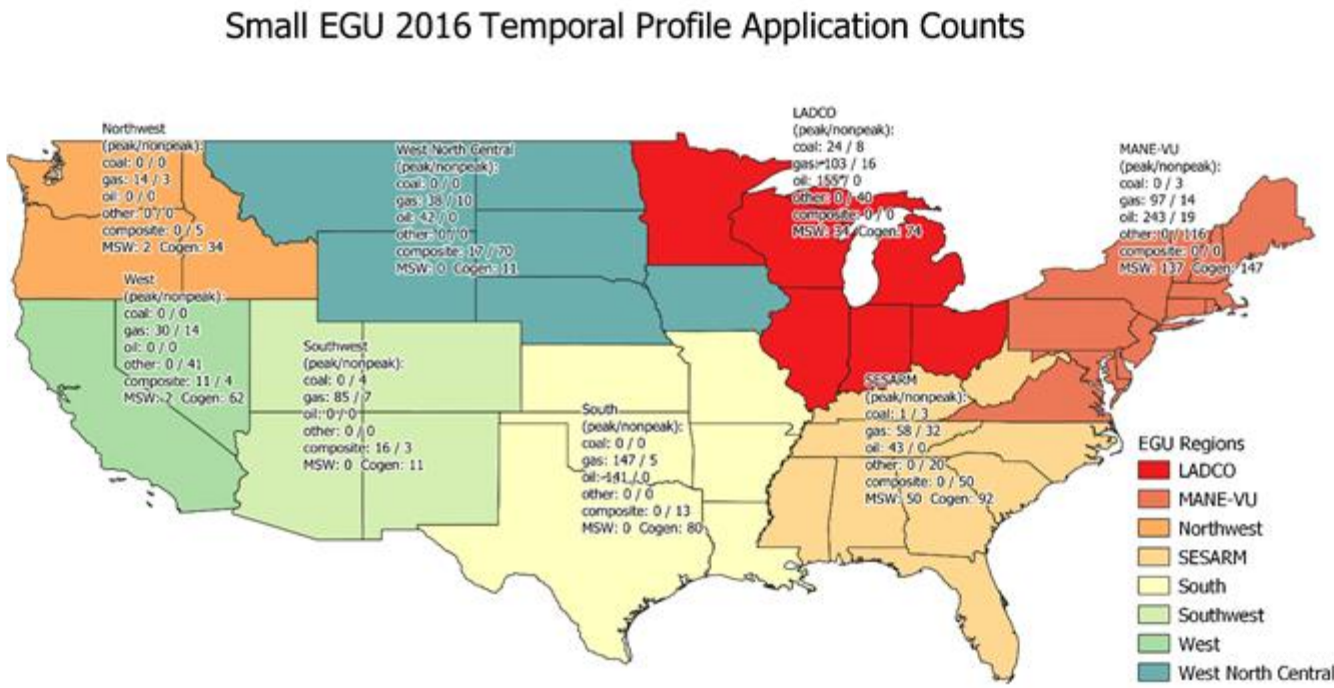


Figure 3-8. Example Diurnal Temporal Profiles for the MANE-VU Region and the Coal Fuel Type



SMOKE uses a cross-reference file to select a monthly, daily, and diurnal profile for each source. For the 2016 platforms, the temporal profiles were assigned in the cross-reference at the unit level to EGU sources without hourly CEMS data. An inventory of all EGU sources without CEMS data was used to identify the region, fuel type, and type (peaking/non-peaking) of each source. As with the input unit the regions are assigned using the state from the unit FIPS. The fuel was assigned by SCC to one of the four fuel types: coal, gas, oil, and other. A fuel type unit assignment is made by summing the VOC, NOX, PM2.5, and SO2 for all SCCs in the unit. The SCC that contributed the highest total emissions to the unit for selected pollutants was used to assign the unit fuel type. Peaking units were identified as any unit with an oil, gas, or oil fuel type with a NAICS of 22111 or 221112. Some units may be assigned to a fuel type within a region that does not have an available input unit with a matching fuel type in that region. These units without an available profile for their group were assigned to use the regional composite profile. MWC and cogen units were identified using the NEEDS primary fuel type and cogeneration flag, respectively, from the NEEDS v6 database. The number of EGU units assigned each profile group are shown by region in Figure 3-9.

Figure 3-9. Non-CEMS EGU Temporal Profile Application Counts



3.3.2.2 Analytic year temporal allocation of EGUs

For analytic year temporal allocation of unit-level EGU emissions, estimates of average winter (representing December through February), average winter shoulder (October through November and March through April), and average summer (May through September) values were provided by the IPM for all units. The winter shoulder was newly separated from the winter months starting with the 2016v2 platform and continuing for the 2016v3 platform. The seasonal emissions for the analytic year cases were produced by post processing of the IPM outputs. The unit-level data were converted into hourly values through the temporal allocation process using a 3-step methodology: annualized summer/winter value to month, month to day, and day to hour. CEMS data from the air quality analysis year (e.g., 2016) is used as much as possible to temporally allocate the EGU emissions.

The goal of the temporal allocation process is to reflect the variability in the unit-level emissions that can impact air quality over seasonal, daily, or hourly time scales, in a manner compatible with incorporating analytic-year emission projections into analytic-year air quality modeling. The temporal allocation process is applied to the seasonal emission projections for the three IPM seasons: summer (May through September), winter shoulder (October through November and March through April), and winter (December through February). The Flat File used as the input to the temporal allocation process contains unit-level emissions and stack parameters (i.e., stack location and other characteristics consistent with information found in the NEI). When the Flat File is produced from post-processed IPM outputs, a cross reference is used to map the units in version 6 of the NEEDS database to the stack parameter and facility, unit, release point, and process identifiers used in the NEI. This cross reference also maps sources to the hourly CEMS data used to temporally allocate the emissions in the base year air quality modeling.

All units have seasonal information provided in the analytic year Flat File, the monthly values in the Flat File input to the temporal allocation process are computed by multiplying the average summer day, average winter shield day, and average winter day emissions by the number of days in the respective month. When generating seasonal emissions totals from the Flat File winter shield emissions are summed with the winter emissions to create a total winter season. In summary, the monthly emission values shown in the Flat File are not intended to represent an actual month-to-month emission pattern. Instead, they are interim values that have translated IPM's seasonal projections into month-level data that serve as a starting point for the temporal allocation process.

The monthly emissions within the Flat File undergo a multi-step temporal allocation process to yield the hourly emission values at each unit, as is needed for air quality modeling: summer or winter value to month, month to day, and day to hour. For sources not matched to unit-specific CEMS data, the first two steps are done outside of SMOKE and the third step to get to hourly values is done by SMOKE using the daily emissions files created from the first two steps. For each of these three temporal allocation steps, NO_x and SO_2 CEMS data are used to allocate NO_x and SO_2 emissions, while CEMS heat input data are used to allocate all other pollutants. The approach defined here gives priority to temporalization based on the base year CEMS data to the maximum extent possible for both base and analytic year modeling. Prior to using the 2016 CEMS data to develop monthly, daily, and hourly profiles, the CEMS data were processed through the CEMCorrect tool to make adjustments for hours for which data quality flags indicated the data were not measured and that the reported values were much larger than the annual mean emissions for the unit. These adjusted CEMS data were used to compute the monthly, daily, and hourly profiles described below.

For units that have CEMS data available and that have CEMS units matched to the NEI sources, the emissions are temporalized according to the base year (i.e., 2016) CEMS data for that unit and pollutant. For units that are not matched to the NEI or for which CEMS data are not available, the allocation of the seasonal emissions to months is done using average fuel-specific season-to-month factors for both peaking and non-peaking units generated for each of the eight regions shown in Figure 5. These factors are based on a single year of CEMS data for the modeling base year associated with the air quality modeling analysis being performed, such as 2016. The fuels used for creating the profiles for a region were coal, natural gas, oil, and "other". The "other "fuels category is a broad catchall that includes fuels such as wood and waste. Separate profiles are computed for NO_x, SO_2, and heat input, where heat input is used to temporally allocate emissions for pollutants other than NO_x and SO_2. An overall composite profile across all fuels is also computed and can be used in the event that a region has too few units of a fuel type to make a reasonable average profile, or in the case when a unit changes fuels between the base and analytic year and there were previously no units with that fuel in the region containing the unit. A complete description of the generation and application of these regional fuel profiles is available in the base year temporalization section.

The monthly emission values in the Flat File were first reallocated across the months in that season to align the month-to-month emission pattern at each stack with historic seasonal emission patterns. While this reallocation affects the monthly pattern of each unit's analytic-year seasonal emissions, the seasonal totals are held equal to the IPM projection for that unit and season. Second, the reallocated monthly emission values at each stack are disaggregated down to the daily level consistent with historic daily emission patterns in the given month at the given stack using separate profiles for NO_x, SO_2, and heat input. This process helps to capture the influence of meteorological episodes that cause electricity demand to vary from day-to-day, as well as weekday-weekend effects that change demand during the course of a given week. Third, this data set of emission values for each day of the year at each unit is input into SMOKE, which uses temporal profiles to disaggregate the daily values into specific values for each hour of the year.

For units without or not matched to CEMS data, or for which the CEMS data are found to be unsuitable for use in the analytic year, emissions were allocated from month to day using IPM-region and fuel-specific average month-to-day factors based on CEMS data from the base year of the air quality modeling analysis. These instances include units that did not operate in the base year or for which it may not have been possible to match the unit to a specific unit in the NEI. Regional average profiles may be used for some units with CEMS data in the base year when one of the following cases is true: (1) units are projected to have substantially increased emissions in the analytic year compared to its emissions in the base (historic) year; (2) CEMS data were only available for a limited number of hours in that base year; (3) the unit is new in the analytic year; (4) when there were no CEMS data for one season in the base year but IPM runs the unit during both seasons; or (5) units experienced atypical conditions during the base year, such as lengthy downtimes for maintenance or installation of controls.

The temporal profiles that map emissions from days to hours were computed based on the region and fuel-specific seasonal (i.e., winter and summer) average day-to-hour factors derived from the CEMS data for heat input for those fuels and regions and for that season. Heat input was used because it is the variable that is the most complete in the CEMS data and should be present for all of the hours in which the unit was operating. SMOKE uses these diurnal temporal profiles to allocate the daily emissions data to hours of each day. Note that this approach results in each unit having the same hourly temporal allocation for all the days of a season.

The emissions from units for which unit-specific profiles were not used were temporally allocated to hours reflecting patterns typical of the region in which the unit is located. Analysis of CEMS data for units in each of the 8 regions shown in Figure 3-6 revealed that there were differences in the temporal patterns of historic emission data that correlate with fuel type (e.g., coal, gas, oil, and other), time of year, pollutant, season (i.e., winter versus summer) and region of the country. The correlation of the temporal pattern with fuel type is explained by the relationship of units' operating practices with the fuel burned. For example, coal units take longer to ramp up and ramp down than natural gas units, and some oil units are used only when electricity demand cannot otherwise be met. Geographically, the patterns were less dependent on state location than they were on regional location. Figure 3-7 provides an example of daily profiles for gas fuel in the LADCO region. The EPA developed seasonal average emission profiles, each derived from base year CEMS data for each season across all units sharing both IPM region and fuel type. Figure 3-8 provides an example of seasonal profiles that allocate daily emissions to hours in the MANE-

VU region. These average day-to-hour temporal profiles were also used for sources during seasons of the year for which there were no CEMS data available, but for which IPM predicted emissions in that season. This situation can occur for multiple reasons, including how the CEMS was run at each source in the base year.

For units that do have CEMS data in the base year and were matched to units in the IPM output, the base year CEMS data were scaled so that their seasonal emissions match the IPM-projected totals. The scaling process used the fraction of the unit's seasonal emissions in the base year as computed for each hour of the season, and then applied those fractions to the seasonal emissions from the analytic year Flat File. Any pollutants other than NO_x and SO_2 were temporally allocated using heat input. Through the temporal allocation process, the analytic year emissions will have the same temporal pattern as the base year CEMS data, where available, while the analytic-year seasonal total emissions for each unit match the analytic-year unit-specific projection for each season (see example in Figure 3-10). The year IPM output for 2025 maps to the year 2026 and was therefore used for the 2026 modeling case.

In cases when the emissions for a particular unit are projected to be substantially higher in the analytic year than in the base year, the proportional scaling method to match the emission patterns in the base year described above can yield emissions for a unit that are much higher than the historic maximum emissions for that unit. To help address this issue in the analytic case, the maximum measured emissions of NO_x and SO_2 in the period of 2014-2017 were computed. The temporally allocated emissions were then evaluated at each hour to determine whether they were above this maximum. The amount of "excess emissions" over the maximum were then computed. For units for which the "excess emissions" could be reallocated to other hours, those emissions were distributed evenly to hours that were below the maximum. Those hourly emissions were then reevaluated against the maximum, and the procedure of reallocating the excess emissions to other hours was repeated until all of the hours had emissions below the maximum, whenever possible (see example in Figure 3-11).

Figure 3-10. Analytic Year Emissions Follow the Pattern of Base Year Emissions

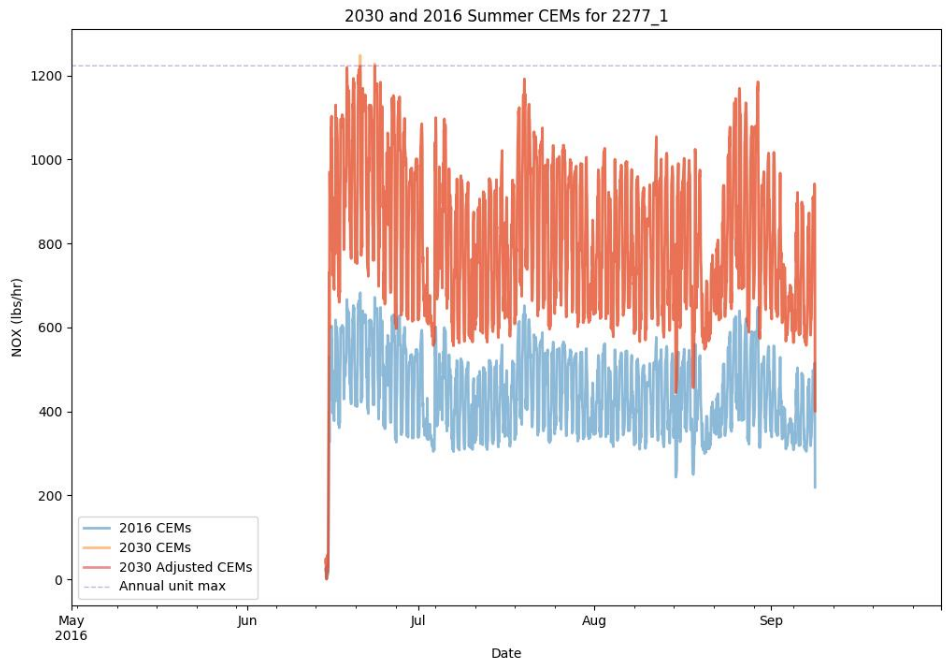
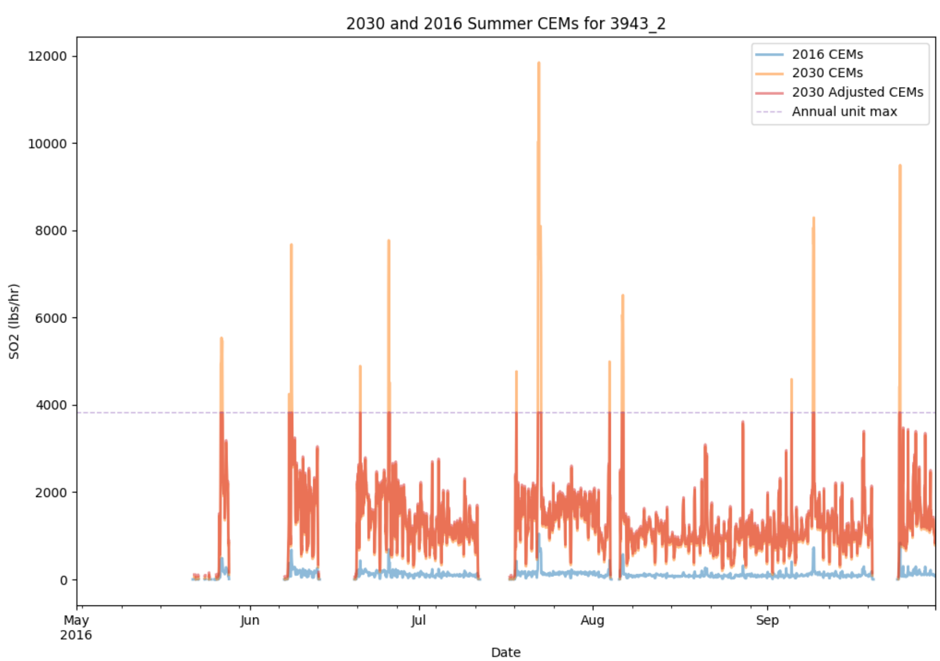


Figure 3-11. Excess Emissions Apportioned to Hours Less than the Historic Maximum



Using the above approach, it was not always possible to reallocate excess emissions to hours below the historic maximum, such as when the total seasonal emissions of NO_x or SO_2 for a unit divided by the number of hours of operation are greater than the 2014-2017 maximum emissions level. For these units, the regional fuel-specific average profiles were applied to all pollutants, including heat input, for the respective season (see example in Figure 3-12). It was not possible for SMOKE to use regional profiles for some pollutants and adjusted CEMS data for other pollutants for the same unit and season, therefore, all pollutants in the unit and season are assigned to regional profiles when regional profiles are needed. For some units, hourly emissions values still exceed the 2014-2017 annual maximum for the unit even after regional profiles were applied (see example in Figure 3-13).

Figure 3-12. Regional Profile Applied due to not being able to Adjust below Historic Maximum

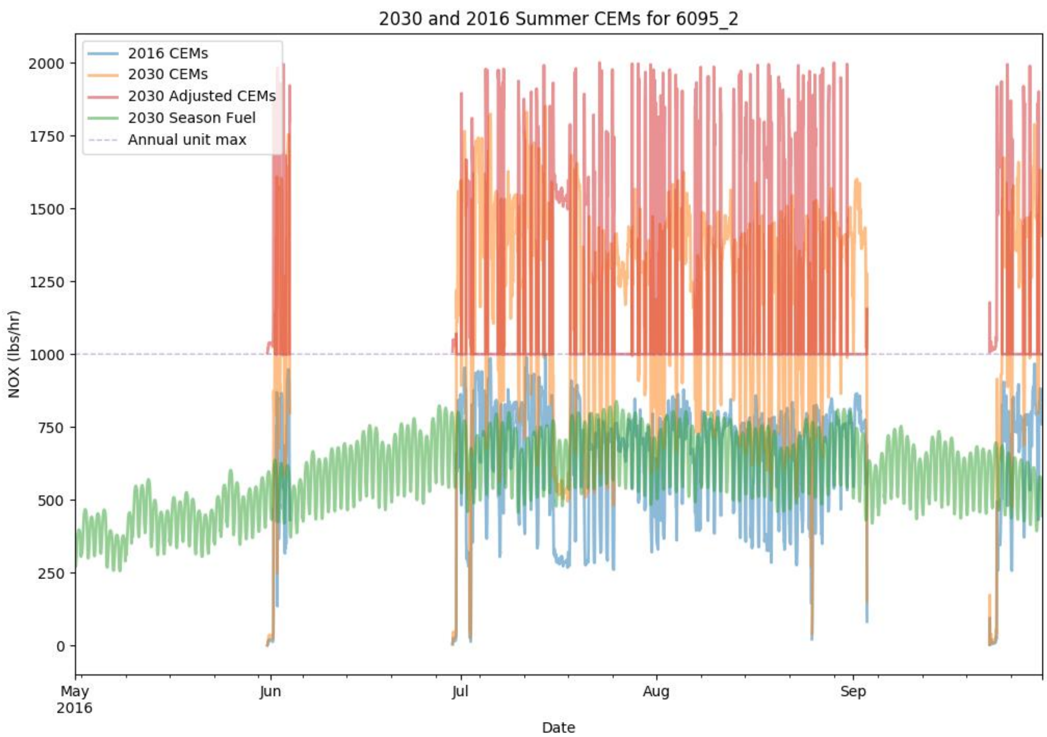
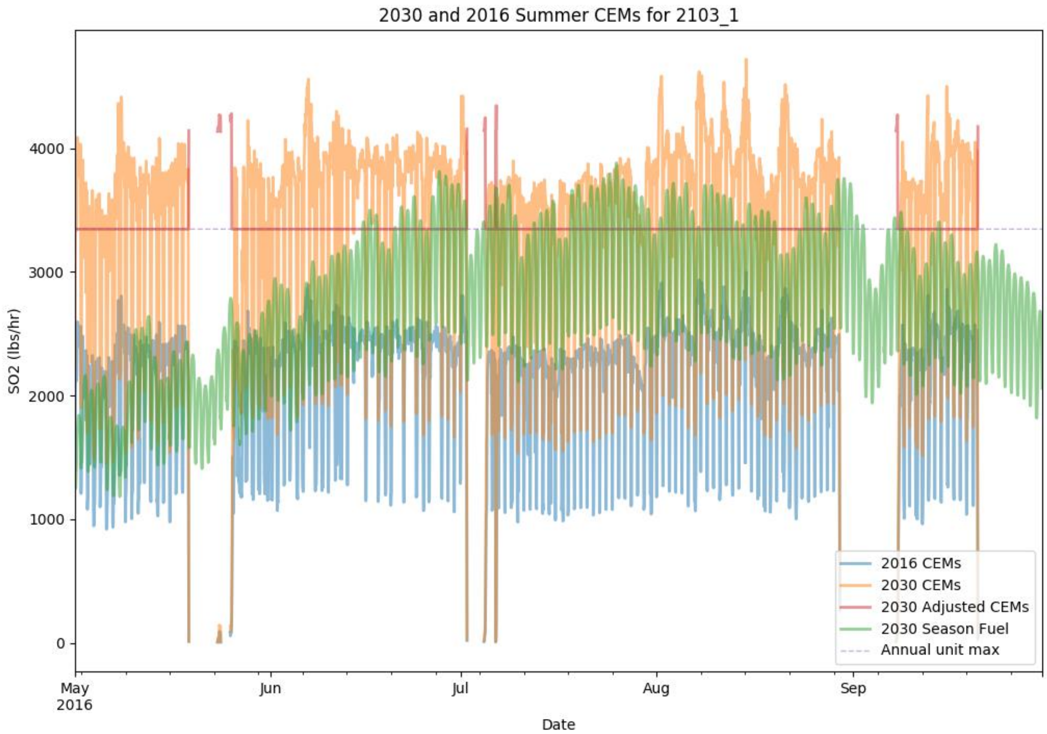


Figure 3-13. Regional Profile Applied, but Exceeds Historic Maximum in Some Hours



3.3.3 Airport Temporal allocation (airports)

Airport temporal profiles were updated in 2014v7.0 and were kept the same for the 2016v3 platform. All airport SCCs (i.e., 2275*, 2265008005, 2267008005, 2268008005 and 2270008005) were given the same hourly, weekly and monthly profile for all airports other than Alaska seaplanes (which are not in the CMAQ modeling domain). Hourly airport operations data were obtained from the Aviation System Performance Metrics (ASPM) Airport Analysis website (https://aspm.faa.gov/apm/sys/AnalysisAP.asp). A report of 2014 hourly Departures and Arrivals for Metric Computation was generated. An overview of the ASPM metrics is at http://aspmhelp.faa.gov/index.php/Aviation_Performance_Metrics_%28APM%29. Figure 3-14 shows the diurnal airport profile.

Weekly and monthly temporal profiles are based on 2014 data from the FAA Operations Network Air Traffic Activity System (http://aspm.faa.gov/opsnet/sys/Terminal.asp). A report of all airport operations (takeoffs and landings) by day for 2014 was generated. These data were then summed to month and day-of-week to derive the monthly and weekly temporal profiles shown in Figure 3-14, Figure 3-15, and Figure 3-16. An overview of the Operations Network data system is at http://aspmhelp.faa.gov/index.php/Operations_Network_%28OPSNET%29. The weekly and monthly profiles from 2014 are still used in the 2016 platforms.

Alaska seaplanes, which are outside the CONUS domain use the same monthly profile as in the 2011 platform shown in Figure 3-17. These were assigned based on the facility ID.

Figure 3-14. Diurnal Profile for all Airport SCCs

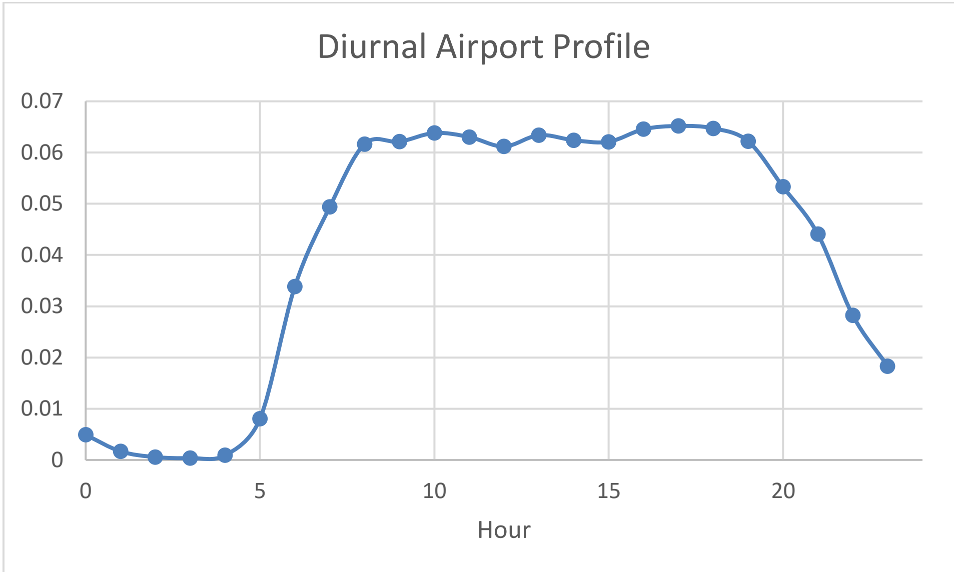


Figure 3-15. Weekly profile for all Airport SCCs

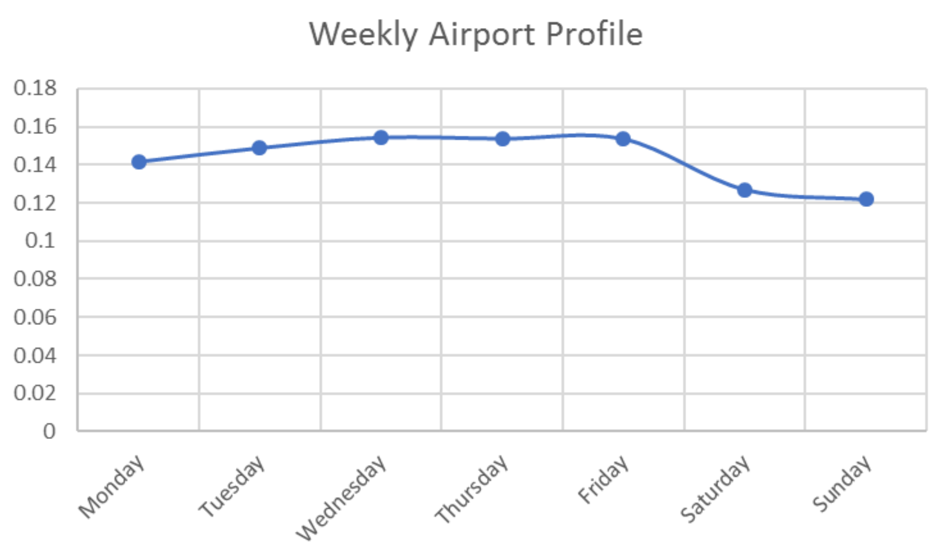


Figure 3-16. Monthly Profile for all Airport SCCs

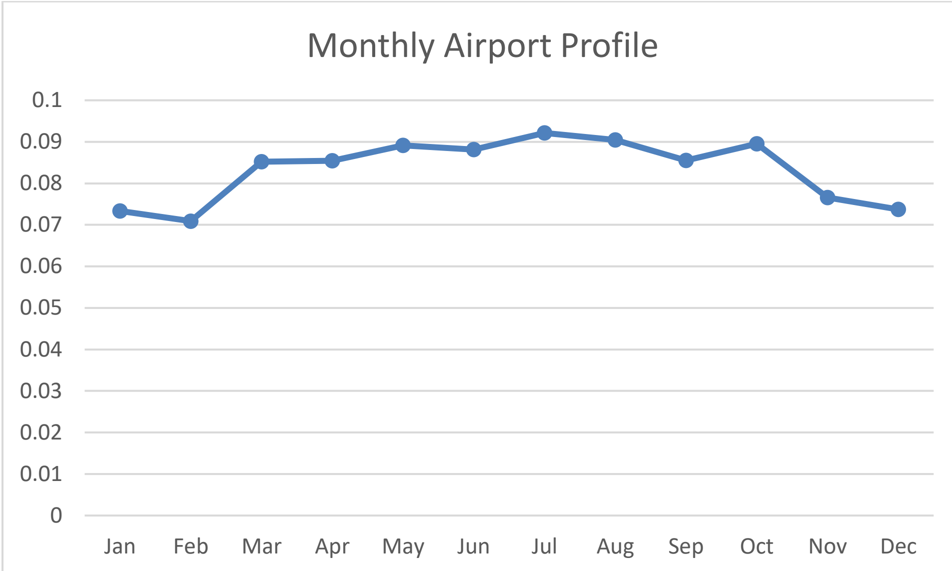
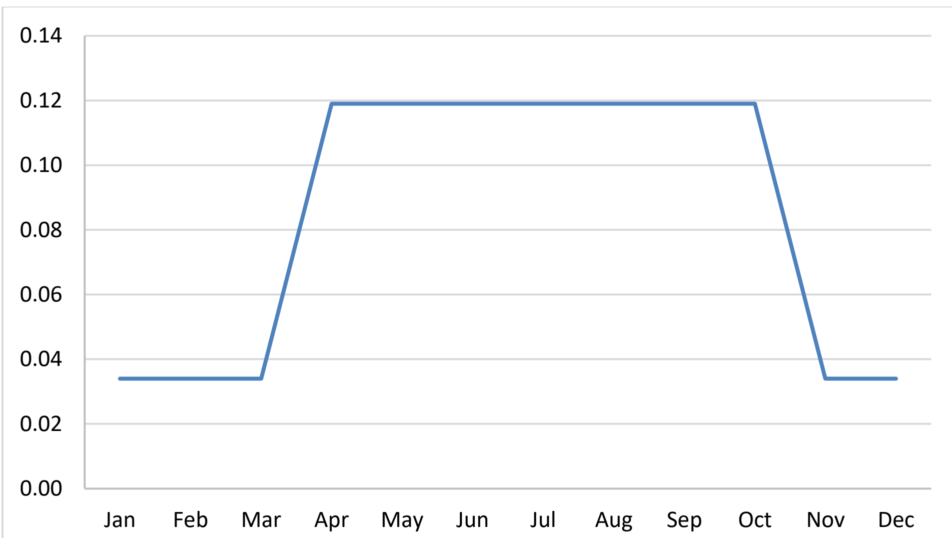


Figure 3-17. Alaska Seaplane Profile



3.3.4 Residential Wood Combustion Temporal allocation (rwc)

There are many factors that impact the timing of when emissions occur, and for some sectors this includes meteorology. The benefits of utilizing meteorology as a method for temporal allocation are: (1) a meteorological dataset consistent with that used by the AQ model is available (e.g., outputs from WRF); (2) the meteorological model data are highly resolved in terms of spatial resolution; and (3) the meteorological variables vary at hourly resolution and can, therefore, be translated into hour-specific temporal allocation.

The SMOKE program Gentpro provides a method for developing meteorology-based temporal allocation. Currently, the program can utilize three types of temporal algorithms: annual-to-day temporal allocation for residential wood combustion (RWC); month-to-hour temporal allocation for agricultural livestock

NH_3; and a generic meteorology-based algorithm for other situations. Meteorological-based temporal allocation was used for portions of the rwc sector and for the entire ag sector.

Gentpro reads in gridded meteorological data (output from MCIP) along with spatial surrogates and uses the specified algorithm to produce a new temporal profile that can be input into SMOKE. The meteorological variables and the resolution of the generated temporal profile (hourly, daily, etc.) depend on the selected algorithm and the run parameters. For more details on the development of these algorithms and running Gentpro, see the Gentpro documentation and the SMOKE documentation at http://www.cmascenter.org/smoke/documentation/3.1/GenTPRO_TechnicalSummary_Aug2012_Final.pdf and https://www.cmascenter.org/smoke/documentation/4.5/html/ch05s03s05.html, respectively.

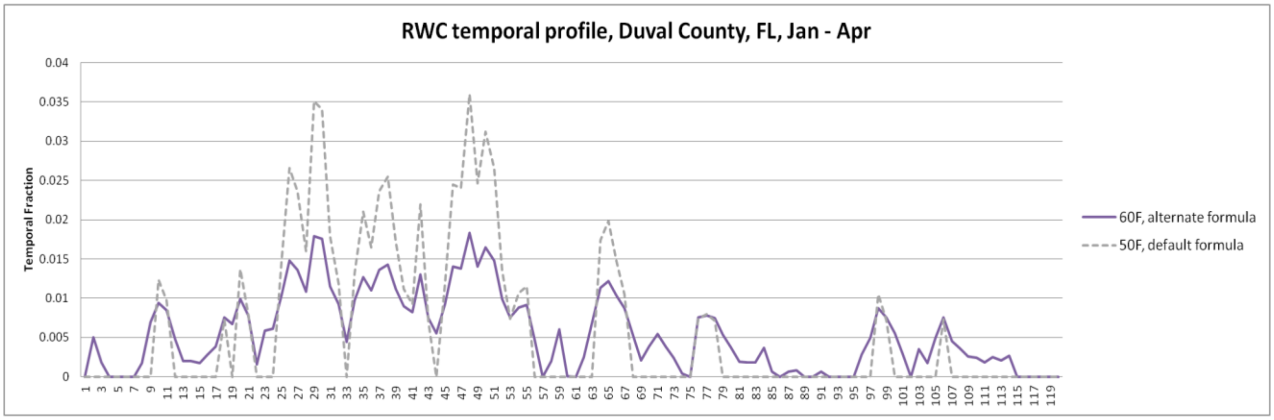
For the RWC algorithm, Gentpro uses the daily minimum temperature to determine the temporal allocation of emissions to days of the year. Gentpro was used to create an annual-to-day temporal profile for the RWC sources. These generated profiles distribute annual RWC emissions to the coldest days of the year. On days where the minimum temperature does not drop below a user-defined threshold, RWC emissions for most sources in the sector are zero. Conversely, the program temporally allocates the largest percentage of emissions to the coldest days. Similar to other temporal allocation profiles, the total annual emissions do not change, only the distribution of the emissions within the year is affected. The temperature threshold for RWC emissions was 50 ˚F for most of the country, and 60 ˚F for the following states: Alabama, Arizona, California, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. The algorithm is as follows:

> If Td >= Tt: no emissions that day
> If Td < Tt: daily factor = 0.79*(Tt -Td)
>
> where (Td = minimum daily temperature; Tt = threshold temperature, which is 60 degrees F in southern states and 50 degrees F elsewhere).

Once computed, the factors are normalized to sum to 1 to ensure that the total annual emissions are unchanged (or minimally changed) during the temporal allocation process.

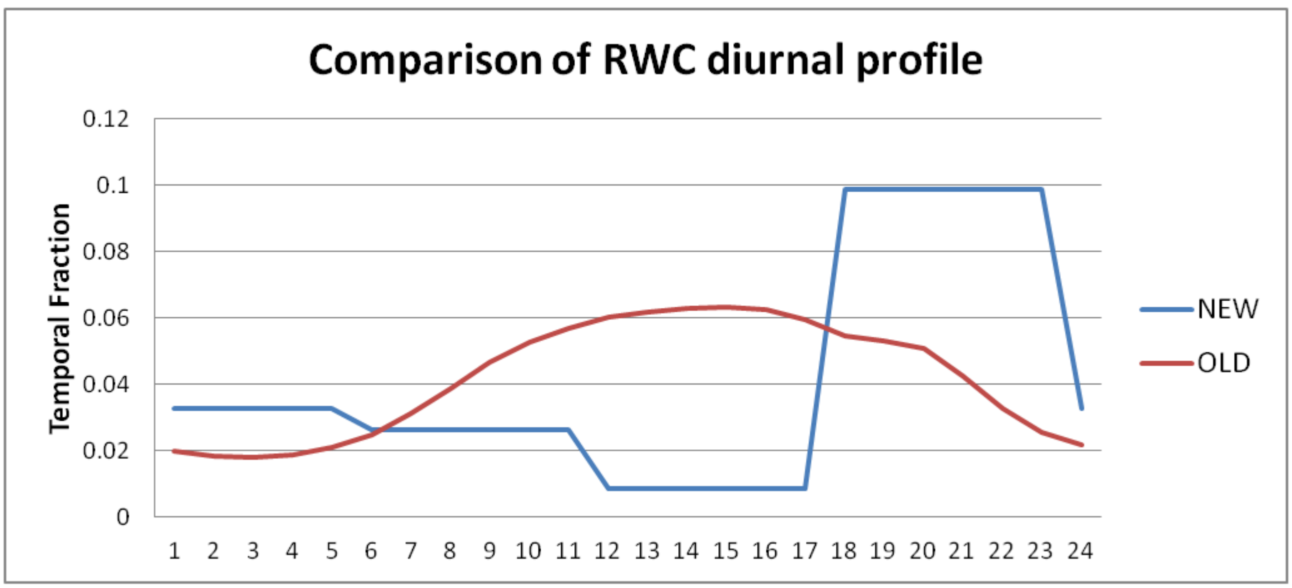
Figure 3-18 illustrates the impact of changing the temperature threshold for a warm climate county. The plot shows the temporal fraction by day for Duval County, Florida, for the first four months of 2007. The default 50 ˚F threshold creates large spikes on a few days, while the 60 ˚F threshold dampens these spikes and distributes a small amount of emissions to the days that have a minimum temperature between 50 and 60 ˚F.

Figure 3-18. Example of RWC temporal allocation in 2007 using a 50 versus 60 ˚F threshold



The diurnal profile used for most RWC sources (see Figure 3-19) places more of the RWC emissions in the morning and the evening when people are typically using these sources. This profile is based on a 2004 MANE-VU survey based temporal profiles[34]. This profile was created by averaging three indoor and three RWC outdoor temporal profiles from counties in Delaware and aggregating them into a single RWC diurnal profile. This new profile was compared to a concentration-based analysis of aethalometer measurements in Rochester, New York (Wang *et al.* 2011) for various seasons and days of the week and was found that the new RWC profile generally tracked the concentration based temporal patterns.

Figure 3-19. RWC diurnal temporal profile



The temporal allocation for "Outdoor Hydronic Heaters" (i.e., "OHH," SCC=2104008610) and "Outdoor wood burning device, NEC (fire-pits, chimineas, etc.)" (i.e., "recreational RWC," SCC=21040087000) is not based on temperature data, because the meteorologically-based temporal allocation used for the rest of the rwc sector did not agree with observations for how these appliances are used.

[34] https://s3.amazonaws.com/marama.org/wp-content/uploads/2019/11/13093804/Open_Burning_Residential_Areas_Emissions_Report-2004.pdf

For OHH, the annual-to-month, day-of-week and diurnal profiles were modified based on information in the New York State Energy Research and Development Authority's (NYSERDA) "Environmental, Energy Market, and Health Characterization of Wood-Fired Hydronic Heater Technologies, Final Report" (NYSERDA, 2012), as well as a Northeast States for Coordinated Air Use Management (NESCAUM) report "Assessment of Outdoor Wood-fired Boilers" (NESCAUM, 2006). A Minnesota 2008 Residential Fuelwood Assessment Survey of individual household responses (MDNR, 2008) provided additional annual-to-month, day-of-week, and diurnal activity information for OHH as well as recreational RWC usage.

Data used to create the diurnal profile for OHH, shown in Figure 3-20, are based on a conventional single-stage heat load unit burning red oak in Syracuse, New York. As shown in Figure 3-21, the NESCAUM report describes how for individual units, OHH are highly variable day-to-day but that in the aggregate, these emissions have no day-of-week variation. In contrast, the day-of-week profile for recreational RWC follows a typical "recreational" profile with emissions peaked on weekends.

Annual-to-month temporal allocation for OHH as well as recreational RWC were computed from the MDNR 2008 survey and are illustrated in Figure 3-22. The OHH emissions still exhibit strong seasonal variability, but do not drop to zero because many units operate year-round for water and pool heating. In contrast to all other RWC appliances, recreational RWC emissions are used far more frequently during the warm season.

Figure 3-20. Data used to produce a diurnal profile for OHH, based on heat load (BTU/hr)

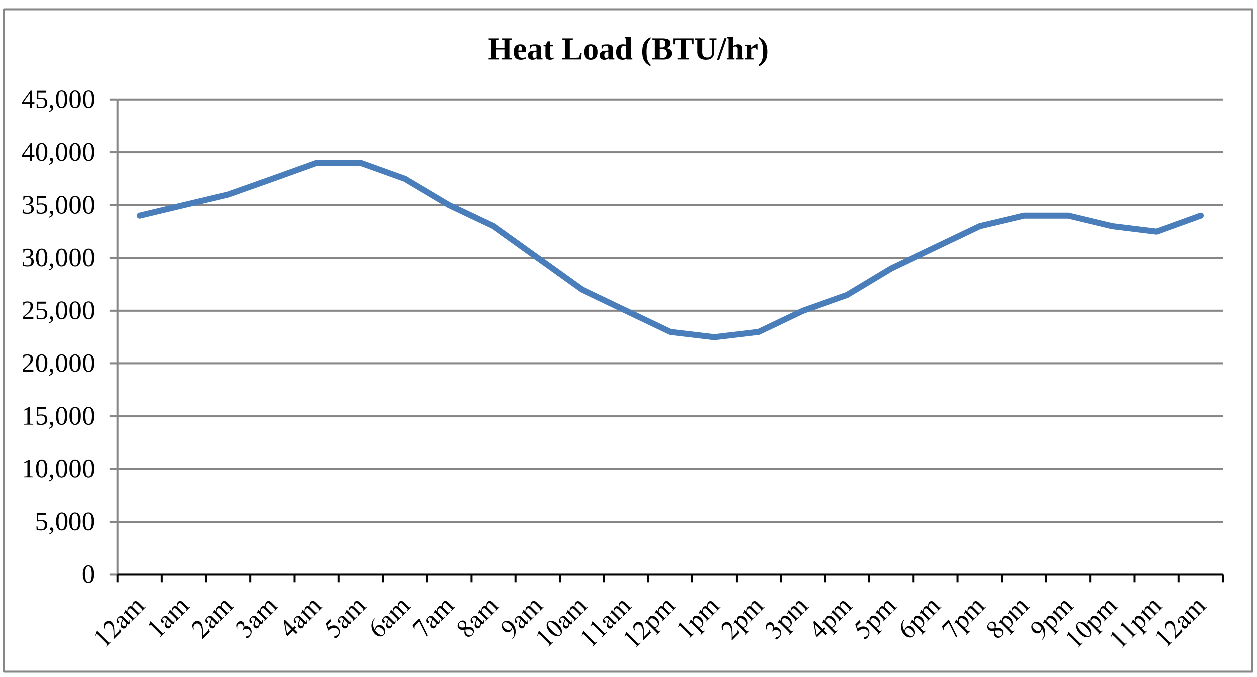


Figure 3-21. Day-of-week temporal profiles for OHH and Recreational RWC

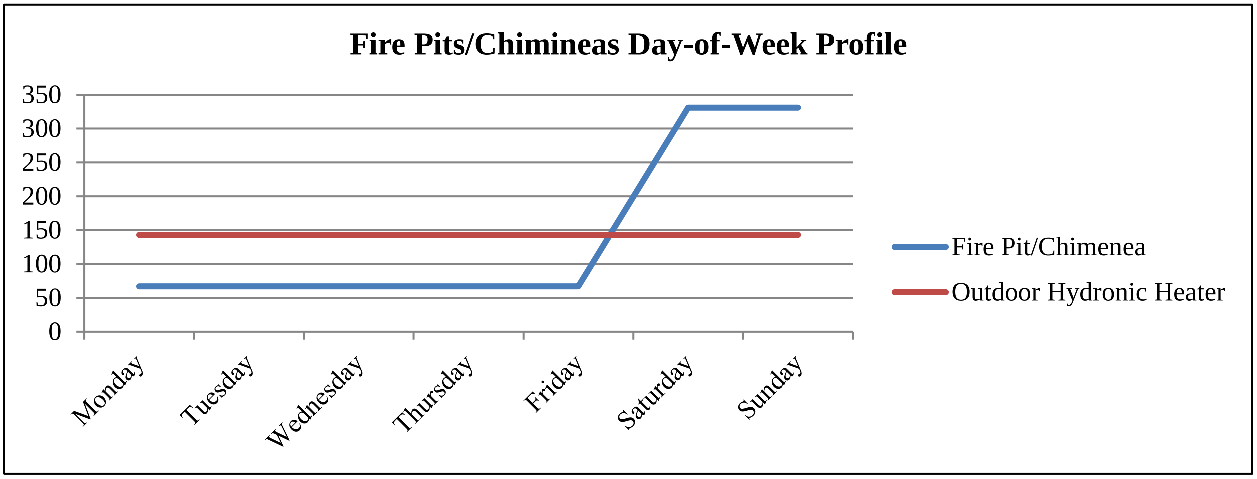
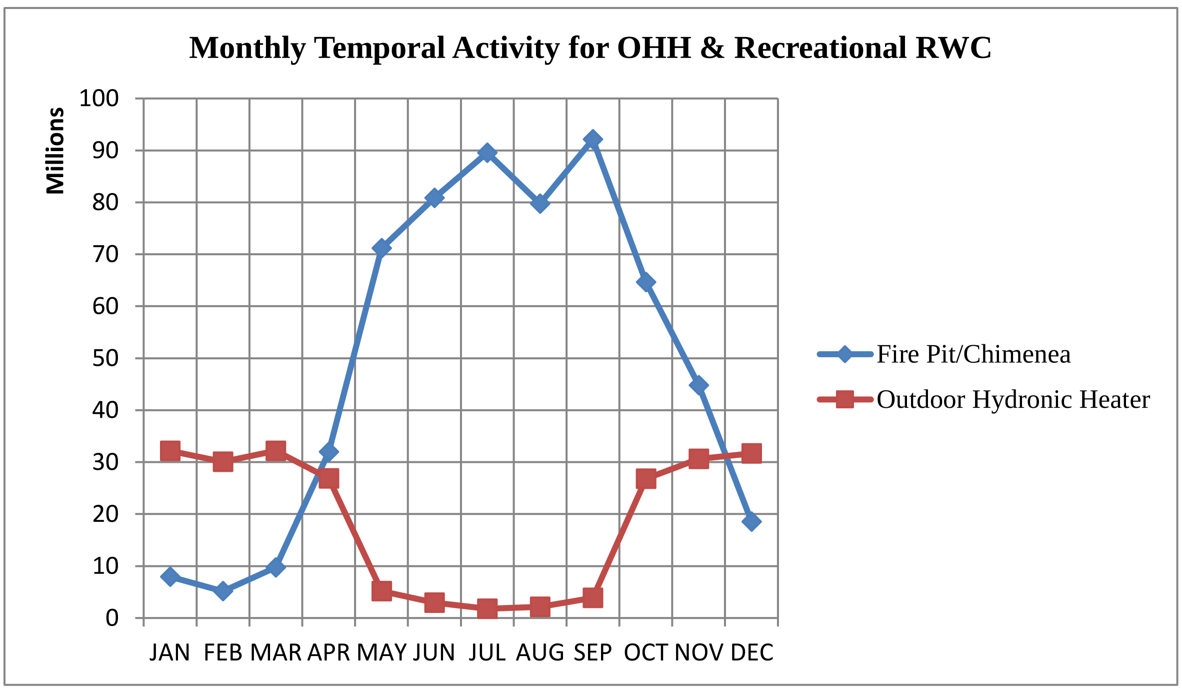


Figure 3-22. Annual-to-month temporal profiles for OHH and recreational RWC



3.3.5 Agricultural Ammonia Temporal Profiles (ag)

For the agricultural livestock NH_3 algorithm, the GenTPRO algorithm is based on an equation derived by Jesse Bash of the EPA's ORD based on the Zhu, Henze, et al. (2013) empirical equation. This equation is based on observations from the TES satellite instrument with the GEOS-Chem model and its adjoint to estimate diurnal NH_3 emission variations from livestock as a function of ambient temperature, aerodynamic resistance, and wind speed. The equations are:

$E_{i,h} = [161500/T_{i,h} \times e^{(-1380/T_{i,h})}] \times AR_{i,h}$ Equation 3-4

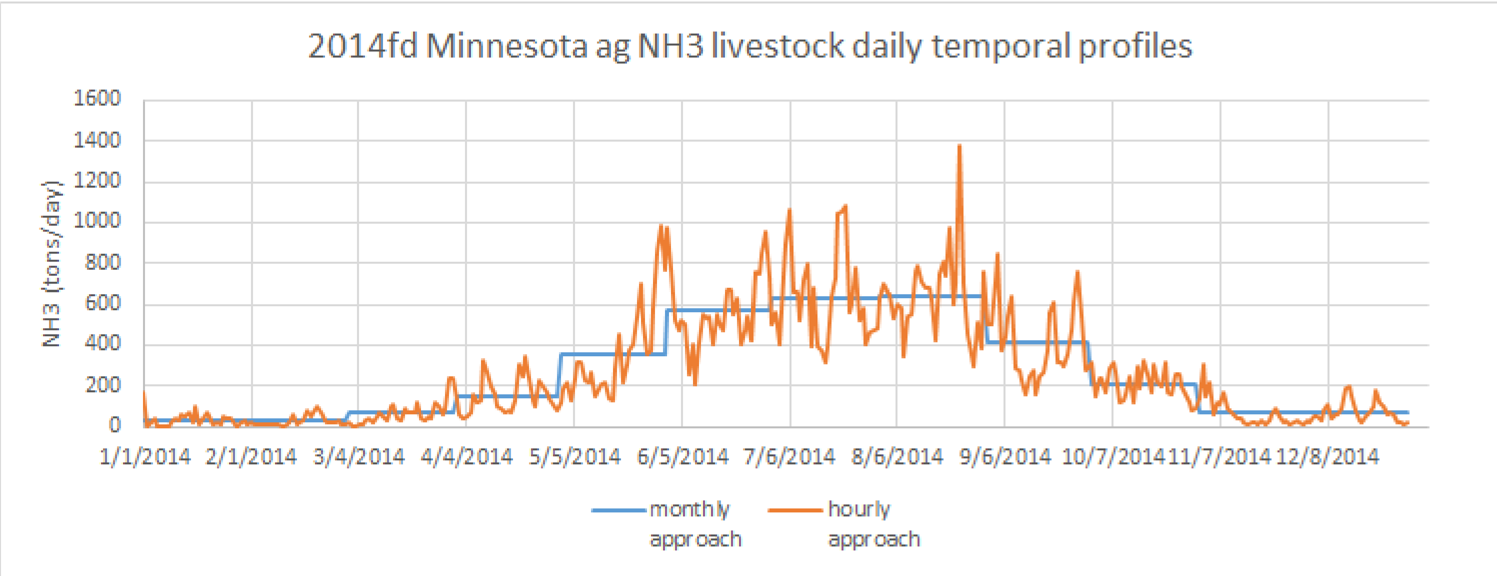
$PE_{i,h} = E_{i,h} / Sum(E_{i,h})$ Equation 3-5

where

- $PE_{i,h}$ = Percentage of emissions in county *i* on hour *h*
- $E_{i,h}$ = Emission rate in county *i* on hour *h*
- $T_{i,h}$ = Ambient temperature (Kelvin) in county *i* on hour *h*
- $AR_{i,h}$ = Aerodynamic resistance in county *i*

GenTPRO was run using the "BASH_NH3" profile method to create month-to-hour temporal profiles for these sources. Because these profiles distribute to the hour based on monthly emissions, the monthly emissions are obtained from a monthly inventory, or from an annual inventory that has been temporalized to the month. Figure 3-23 compares the daily emissions for Minnesota from the "old" approach (uniform monthly profile) with the "new" approach (GenTPRO generated month-to-hour profiles) for 2014. Although the GenTPRO profiles show daily (and hourly variability), the monthly total emissions are the same between the two approaches.

Figure 3-23. Example of animal NH_3 emissions temporal allocation approach (daily total emissions)



For the 2016 platform, the GenTPRO approach is applied to all sources in the livestock and fertilizer sectors, NH_3 and non- NH_3. Monthly profiles are based on the daily-based EPA livestock emissions and are the same as those used in 2014v7.0. Profiles are by state/SCC_category, where SCC_category is one of the following: beef, broilers, layers, dairy, swine.

3.3.6 Oil and gas temporal allocation (np_oilgas)

Monthly oil and gas temporal profiles by county and SCC were updated to use 2016 activity information for the 2016v1 platform. Weekly and diurnal profiles are flat and are based on comments received on a version of the 2011 platform.

3.3.7 Onroad mobile temporal allocation (onroad)

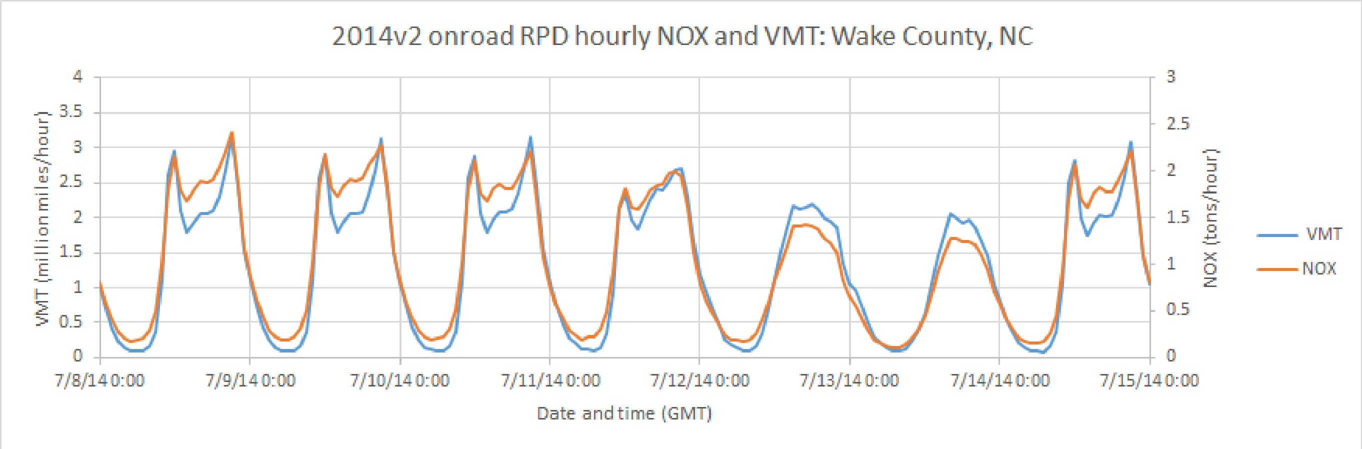
For the onroad sector, the temporal distribution of emissions is a combination of traditional temporal profiles and the influence of meteorology. This section will discuss both the meteorological influences and the development of the temporal profiles for this platform.

The "inventories" referred to in Table 3-20 consist of activity data for the onroad sector, not emissions. For the off-network emissions from the rate-per-profile (RPP) and rate-per-vehicle (RPV) processes, the VPOP activity data is annual and does not need temporal allocation. For rate-per-hour (RPH) processes that result from hoteling of combination trucks, the HOTELING inventory is annual and was temporalized to month, day of the week, and hour of the day through temporal profiles. Day-of-week and hour-of-day temporal profiles are also used to temporalize the starts activity used for rate-per-start (RPS) processes, and the off-network idling (ONI) hours activity used for rate-per-hour-ONI (RPHO) processes. The inventories for starts and ONI activity contain monthly activity so that monthly temporal profiles are not needed.

For on-roadway rate-per-distance (RPD) processes, the VMT activity data is annual for some sources and monthly for other sources, depending on the source of the data. Sources without monthly VMT were temporalized from annual to month through temporal profiles. VMT was also temporalized from month to day of the week, and then to hourly through temporal profiles. The RPD processes require a speed profile (SPDPRO) that consists of vehicle speed by hour for a typical weekday and weekend day. For onroad, the temporal profiles and SPDPRO will impact not only the distribution of emissions through time but also the total emissions. Because SMOKE-MOVES (for RPD) calculates emissions based on the VMT, speed and meteorology, if one shifted the VMT or speed to different hours, it would align with different temperatures and hence different emission factors. In other words, two SMOKE-MOVES runs with identical annual VMT, meteorology, and MOVES emission factors, will have different total emissions if the temporal allocation of VMT changes. Figure 3-24 illustrates the temporal allocation of the onroad activity data (i.e., VMT) and the pattern of the emissions that result after running SMOKE-MOVES. In this figure, it can be seen that the meteorologically varying emission factors add variation on top of the temporal allocation of the activity data.

Meteorology is not used in the development of the temporal profiles, but rather it impacts the calculation of the hourly emissions through the program Movesmrg. The result is that the emissions vary at the hourly level by grid cell. More specifically, the on-network (RPD) and the off-network parked vehicle (RPV, RPH, RPHO, RPS, and RPP) processes use the gridded meteorology (MCIP) either directly or indirectly. For RPD, RPV, RPS, RPH, and RPHO, Movesmrg determines the temperature for each hour and grid cell and uses that information to select the appropriate emission factor for the specified SCC/pollutant/mode combination. For RPP, instead of reading gridded hourly meteorology, Movesmrg reads gridded daily minimum and maximum temperatures. The total of the emissions from the combination of these four processes (RPD, RPV, RPH, RPHO, RPS, and RPP) comprise the onroad sector emissions. The temporal patterns of emissions in the onroad sector are influenced by meteorology.

Figure 3-24. Example of temporal variability of NO_X emissions



New VMT day-of-week and hour-of-day temporal profiles were developed for use in the 2014NEIv2 and later platforms as part of the effort to update the inputs to MOVES and SMOKE-MOVES under CRC A-100 (Coordinating Research Council, 2017). CRC A-100 data includes profiles by region or county, road type, and broad vehicle category. There are three vehicle categories: passenger vehicles (11/21/31), commercial trucks (32/52), and combination trucks (53/61/62). CRC A-100 does not cover buses, refuse trucks, or motor homes, so those vehicle types were mapped to other vehicle types for which CRC A-100 did provide profiles as follows: 1) Intercity/transit buses were mapped to commercial trucks; 2) Motor homes were mapped to passenger vehicles for day-of-week and commercial trucks for hour-of-day; 3) School buses and refuse trucks were mapped to commercial trucks for hour-of-day and use a new custom day-of-week profile called LOWSATSUN that has a very low weekend allocation, since school buses and refuse trucks operate primarily on business days. In addition to temporal profiles, CRC A-100 data were also used to develop the average hourly speed data (SPDPRO) used by SMOKE-MOVES. In areas where CRC A-100 data does not exist, hourly speed data is based on MOVES county databases.

The CRC A-100 dataset includes temporal profiles for individual counties, Metropolitan Statistical Areas (MSAs), and entire regions (e.g., West, South). For counties without county or MSA temporal profiles specific to itself, regional temporal profiles are used. Temporal profiles also vary by each of the MOVES road types, and there are distinct hour-of-day profiles for each day of the week. Plots of hour-of-day profiles for passenger vehicles in Fulton County, GA, are shown in Figure 3-25. Separate plots are shown for Monday, Friday, Saturday, and Sunday, and each line corresponds to a particular MOVES road type (i.e., road type 2 = rural restricted, 3 = rural unrestricted, 4 = urban restricted, and 5 = urban unrestricted). Figure 3-26 shows which counties have temporal profiles specific to that county, and which counties use MSA or regional average profiles. Figure 3-27 shows the regions used to compute regional average profiles.

Figure 3-25. Sample onroad diurnal profiles for Fulton County, GA

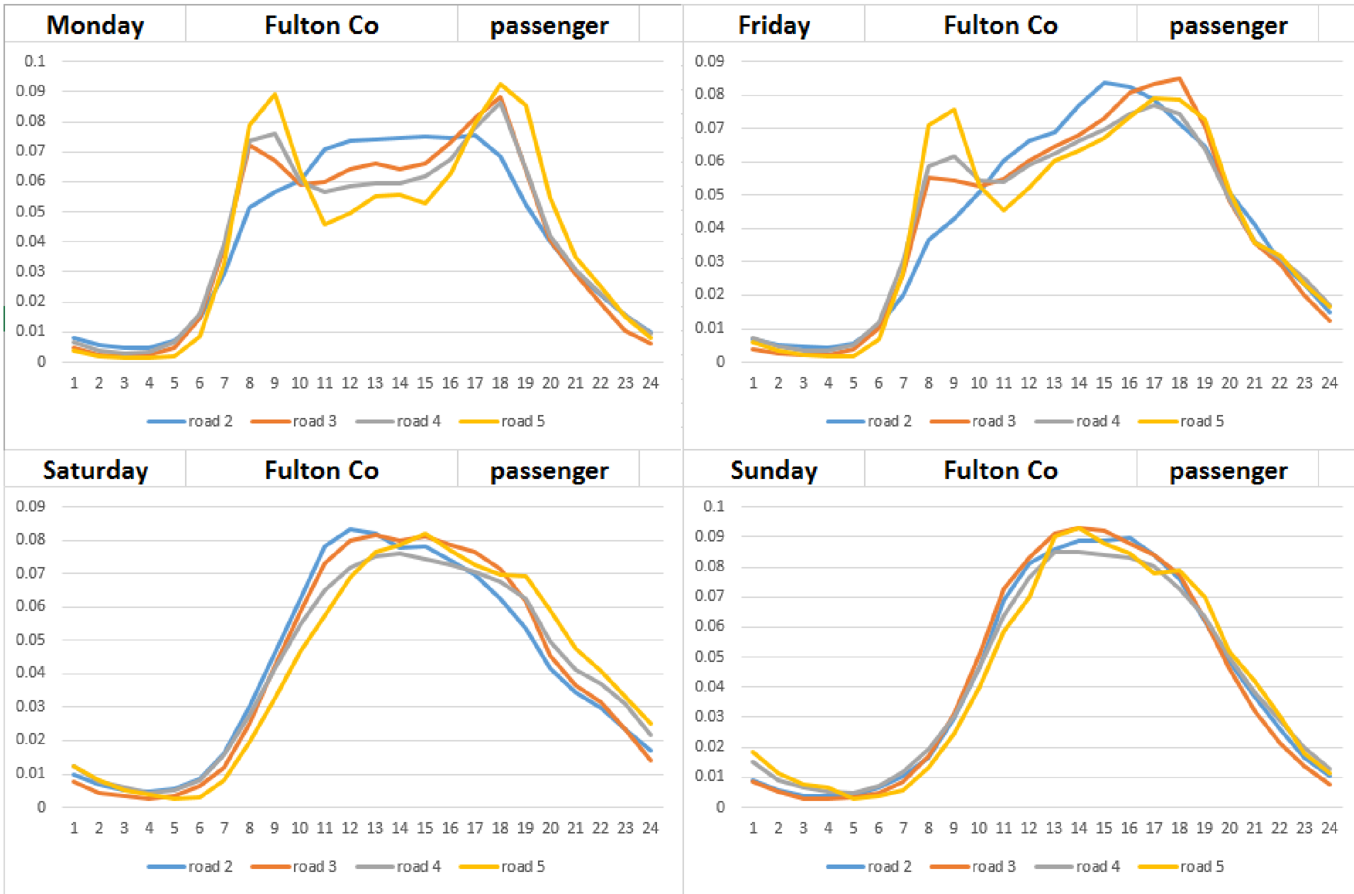


Figure 3-26. Methods to Populate Onroad Speeds and Temporal Profiles by Road Type

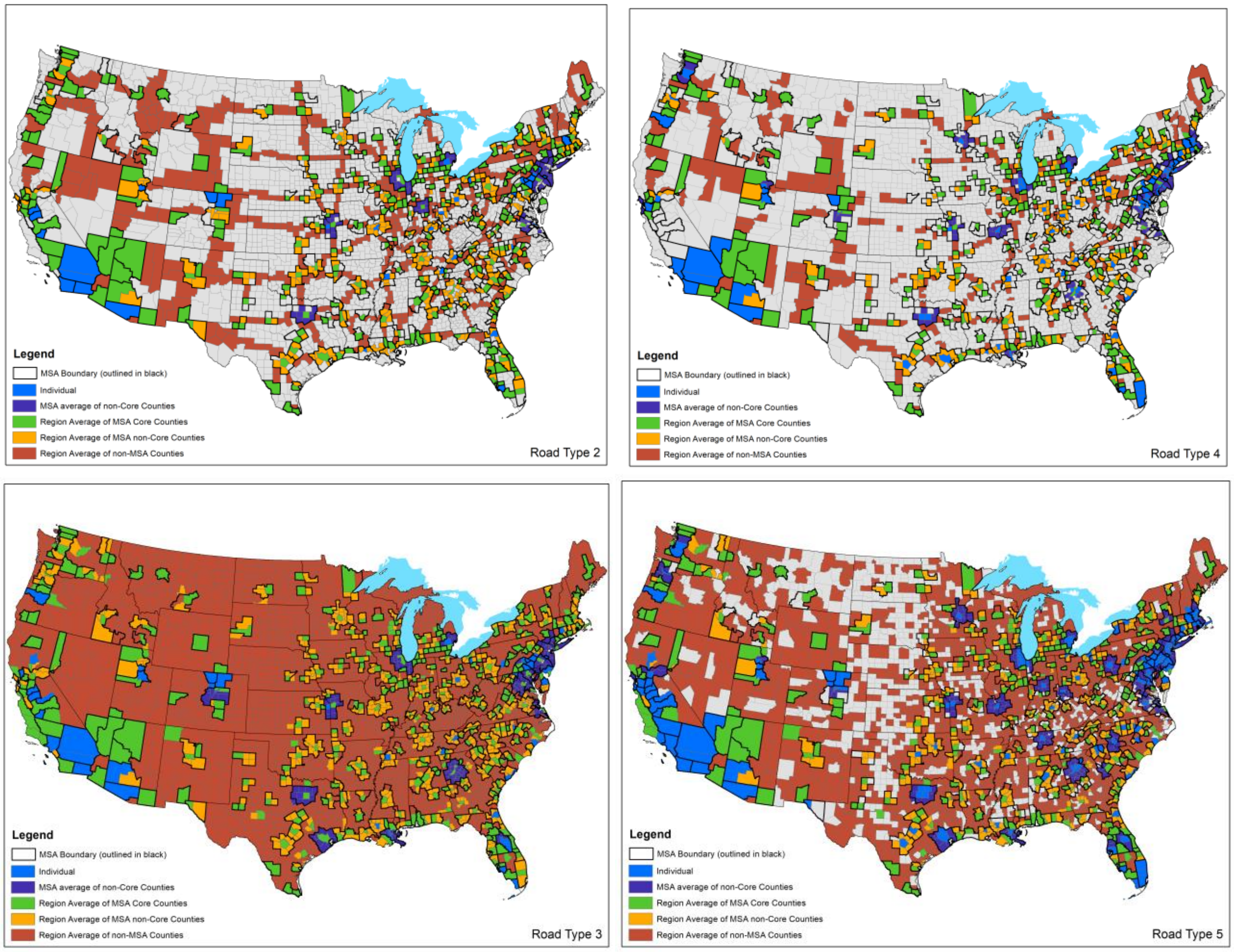
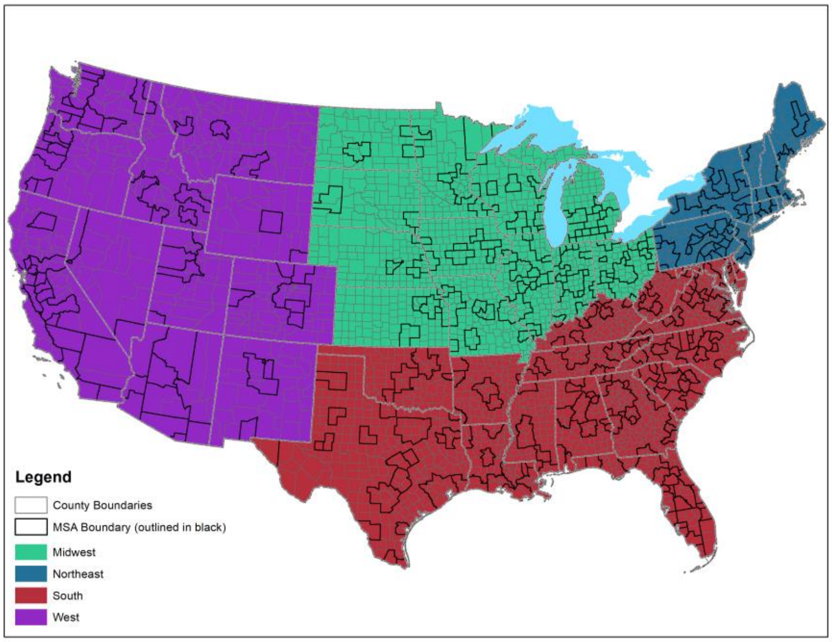


Figure 3-27. Regions for computing Region Average Speeds and Temporal Profiles

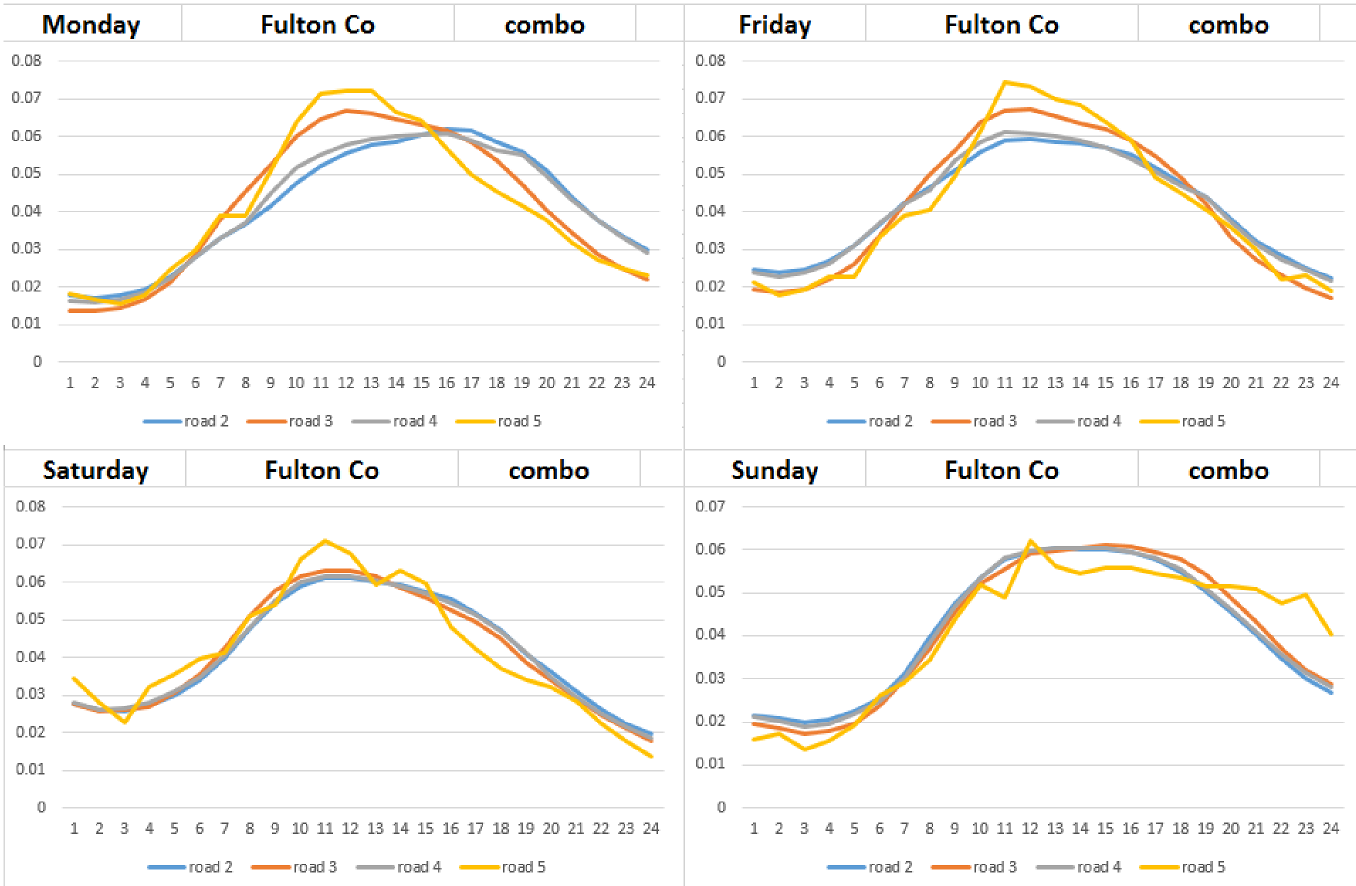


For hoteling, day-of-week profiles are the same as non-hoteling for combination trucks, while hour-of-day non-hoteling profiles for combination trucks were inverted to create new hoteling profiles that peak overnight instead of during the day. The combination truck profiles for Fulton County are shown in Figure 3-28.

The CRC A-100 temporal profiles were used in the entire contiguous United States, except in California. All California temporal profiles were carried over from 2014v7.0, although California hoteling uses CRC A-100-based profiles just like the rest of the country, since CARB didn't have a hoteling-specific profile. Monthly profiles in all states (national profiles by broad vehicle type) were also carried over from 2014v7.0 and applied directly to the VMT. For California, CARB supplied diurnal profiles that varied by vehicle type, day of the week,[35] and air basin. These CARB-specific profiles were used in developing EPA estimates for California. Although the EPA adjusted the total emissions to match California-submitted emissions for 2016, the temporal allocation of these emissions took into account both the state-specific VMT profiles and the SMOKE-MOVES process of incorporating meteorology.

[35] California's diurnal profiles varied within the week. Monday, Friday, Saturday, and Sunday had unique profiles and Tuesday, Wednesday, Thursday had the same profile.

Figure 3-28. Example of Temporal Profiles for Combination Trucks



Temporal profiles for RPHO are based on the same temporal profiles as the on-network processes in RPD, but since the on-network profiles are road-type-specific and ONI is not road-type-specific, the RPHO profiles were assigned to use rural unrestricted profiles for counties considered "rural" and urban unrestricted profiles for counties considered "urban". RPS uses a separate set of temporal profiles specifically for starts activity. For starts, there is one day-of-week temporal profile for each source type (e.g., motorcycles, passenger cars, combination long haul trucks), and two hour-of-day temporal profiles for each source type, one for weekdays and one for weekends. The temporal profiles for starts are applied nationally and are based on the default starts-per-day-per-vehicle and starts-hour-fraction tables from MOVES.

3.3.8 Nonroad mobile temporal allocation(nonroad)

For nonroad mobile sources, temporal allocation is performed differently for different SCCs. Beginning with the final 2011 platform and continued into the 2016 platforms, some improvements to temporal allocation of nonroad mobile sources were made to make the temporal profiles more realistically reflect real-world practices. Some specific updates were made for agricultural sources (e.g., tractors), construction, and commercial residential lawn and garden sources.

Figure 3-29 shows two previously existing temporal profiles (9 and 18) and a new temporal profile (19) which has lower emissions on weekends. In the 2016 platform, construction and commercial lawn and garden sources were updated from profile 18 to the new profile 19 which has lower emissions on weekends. Residental lawn and garden sources continue to use profile 9 and agricultural sources continue to use profile 19.

Figure 3-29. Example Nonroad Day-of-week Temporal Profiles

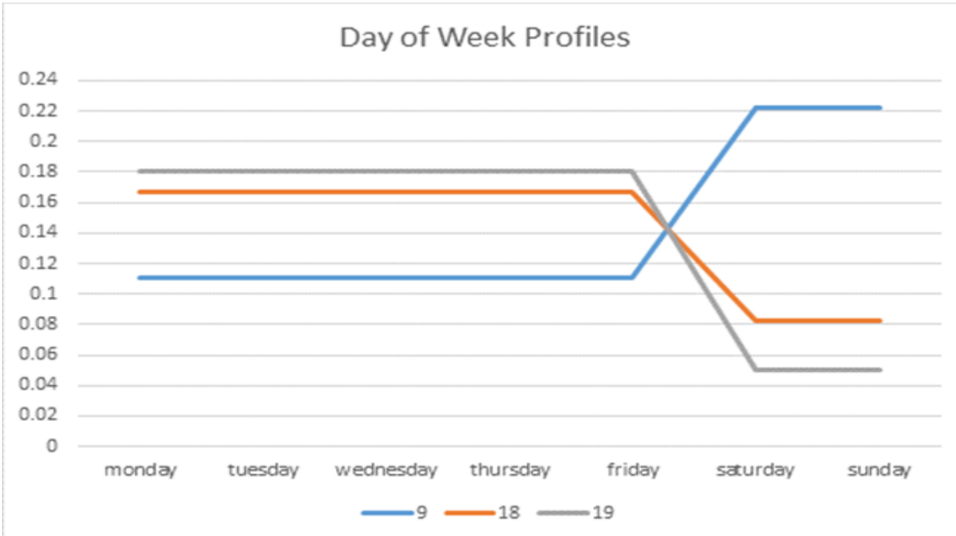
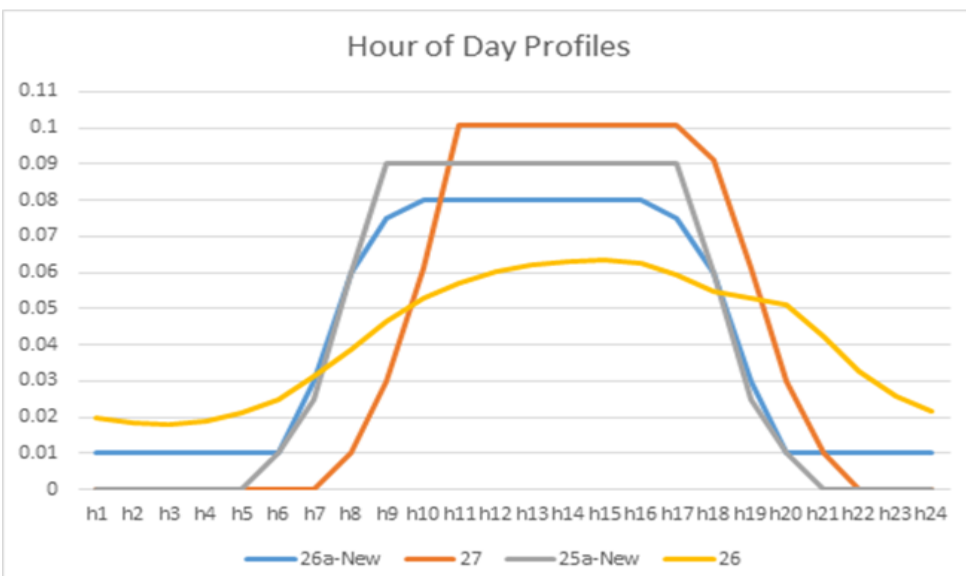


Figure 3-30 shows the previously existing temporal profiles 26 and 27 along with new temporal profiles (25a and 26a) which have lower emissions overnight. In the 2016 platform, construction sources previously used profile 26 and were updated to use profile 26a. Commercial lawn and garden and agriculture sources also previously used profile 26 but were updated to use the new profiles 26a and 25a, respectively. Residental lawn and garden sources were updated from profile 26 to use profile 27.

Figure 3-30. Example Nonroad Diurnal Temporal Profiles



3.3.9 Additional sector specific details (afdust, beis, cmv, rail, nonpt, ptnonipm, ptfire)

For the afdust sector, meteorology is not used in the development of the temporal profiles, but it is used to reduce the total emissions based on meteorological conditions. These adjustments are applied through sector-specific scripts, beginning with the application of land use-based gridded transport fractions and then subsequent zero-outs for hours during which precipitation occurs or there is snow cover on the ground. The land use data used to reduce the NEI emissions explains the amount of emissions that are subject to transport. This methodology is discussed in (Pouliot et al., 2010), and in "Fugitive Dust Modeling for the 2008 Emissions Modeling Platform" (Adelman, 2012). The precipitation adjustment is applied to remove all emissions for hours where measurable rain occurs, or where there is snow cover. Therefore, the afdust emissions vary day-to-day based on the precipitation and/or snow cover for each grid cell and hour. Both the transport fraction and meteorological adjustments are based on the gridded resolution of the platform; therefore, somewhat different emissions will result from different grid resolutions. For this reason, to ensure consistency between grid resolutions, afdust emissions for the 36US3 grid are aggregated from the 12US1 emissions. Application of the transport fraction and meteorological adjustments prevents the overestimation of fugitive dust impacts in the grid modeling as compared to ambient samples.

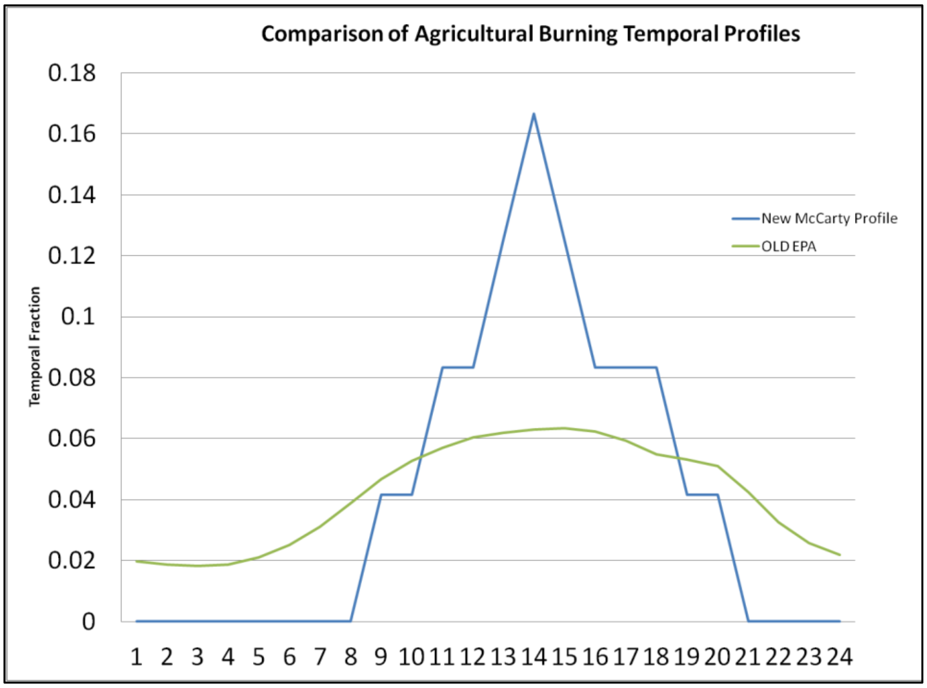
Biogenic emissions in the beis sector vary by every day of the year because they are developed using meteorological data including temperature, surface pressure, and radiation/cloud data. The emissions are computed using appropriate emission factors according to the vegetation in each model grid cell, while taking the meteorological data into account.

For the cmv sectors, most areas use hourly emission inventories derived from the 5-minute AIS data. In some areas where AIS data are not available, such as in Canada between the St. Lawrence Seaway and the Great Lakes and in the southern Caribbean, the flat temporal profiles are used for hourly and day-of-week values. Most regions without AIS data also use a flat monthly profile, with some offshore areas using an average monthly profile derived from the 2008 ECA inventory monthly values. These areas without AIS data also use flat day of week and hour of day profiles.

For the rail sector, new monthly profiles were developed for the 2016 platform. Monthly temporal allocation for rail freight emissions is based on AAR Rail Traffic Data, Total Carloads and Intermodal, for 2016. For passenger trains, monthly temporal allocation is flat for all months. Rail passenger miles data is available by month for 2016 but it is not known how closely rail emissions track with passenger activity since passenger trains run on a fixed schedule regardless of how many passengers are aboard, and so a flat profile is chosen for passenger trains. Rail emissions are allocated with flat day of week profiles, and most emissions are allocated with flat hourly profiles.

For the ptagfire sector, the inventories are in the daily point fire format FF10 PTDAY. The diurnal temporal profile for ag fires reflects the fact that burning occurs during the daylight hours - see Figure 3-31 (McCarty et al., 2009). This puts most of the emissions during the workday and suppresses the emissions during the middle of the night.

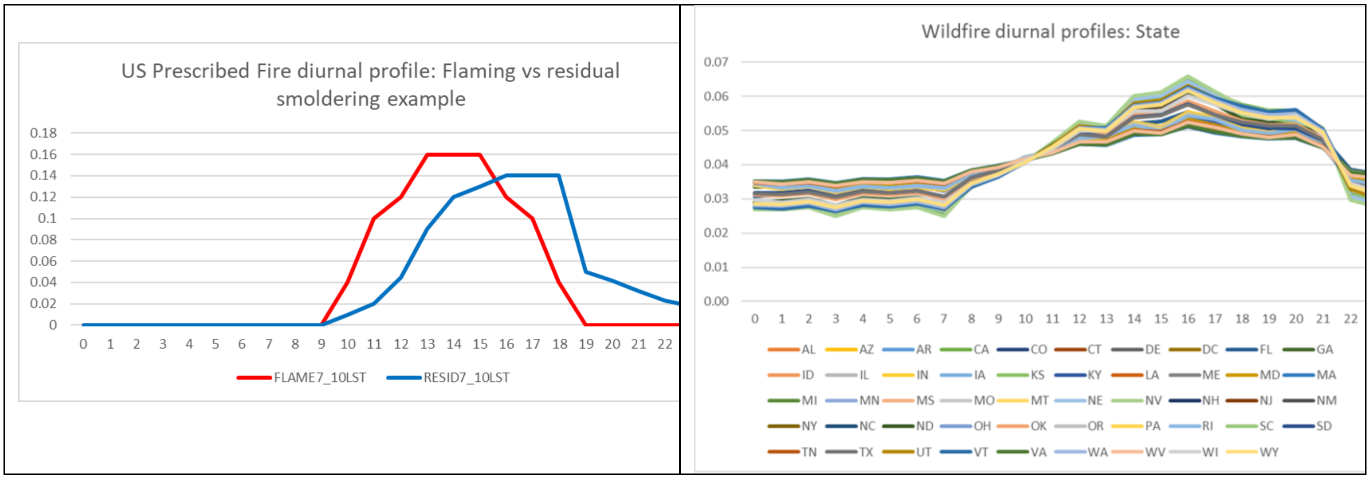
Figure 3-31. Agricultural burning diurnal temporal profile



Industrial processes that are not likely to shut down on Sundays, such as those at cement plants, use profiles that include emissions on Sundays, while those that would shut down on Sundays use profiles that reflect Sunday shutdowns.

For the ptfire sectors, the inventories are in the daily point fire format FF10 PTDAY. Separate hourly profiles for prescribed and wildfires were used. Figure 3-32 below shows the profiles used for each state for the 2016v2 and 2016v3 modeling platforms. The wildfire diurnal profiles are similar but vary according to the average meteorological conditions in each state. The 2016v2 and v3 platforms used diurnal profiles for prescribed profile that better reflect flaming and residual smoldering phases and average burn practices. These flaming and residual smoldering diurnal profiles vary slightly by region.

Figure 3-32. Prescribed and Wildfire diurnal temporal profiles



For the nonroad sector, while the NEI only stores the annual totals, the modeling platform uses monthly inventories from output from MOVES. For California, CARB's annual inventory was temporalized to monthly using monthly temporal profiles applied in SMOKE by SCC. This is an improvement over the 2011 platforms, which applied monthly temporal allocation in California at the broader SCC7 level.

3.4 Spatial Allocation

The methods used to perform spatial allocation are summarized in this section. The spatial factors are typically applied by county and SCC. As described in Section 3.1, spatial allocation was performed for national 36-km and 12-km domains. To accomplish this, SMOKE used national 36-km and 12-km spatial surrogates and a SMOKE area-to-point data file. For the U.S., the spatial surrogates are based on circa 2016 to 2017 data wherever possible. For Mexico, the spatial surrogates used as described below. For Canada, surrogates were provided by ECCC for the 2016v7.2 (beta) platform and those continue to be used in the 2016v3 platform. The U.S., Mexican, and Canadian 36-km and 12-km surrogates cover the entire CONUS domain 12US1 shown in Figure 3-1. The 36US3 domain includes a portion of Alaska, and since Alaska emissions are typically not included in air quality modeling for the contiguous U.S., special considerations are taken to include Alaska emissions in 36-km modeling.

2016v3 platform uses the same surrogates and surrogate assignments as 2016v2 platform, except for new SCCs introduced in the np_solvents sector which did not have an existing assignment. Documentation of the origin of the spatial surrogates for the platform is provided in the 2016v2 surrogate specifications workbook. The remainder of this subsection summarizes the data used for the spatial surrogates and the area-to-point data which is used for airport refueling.

3.4.1 Spatial Surrogates for U.S. emissions

There are more than 100 spatial surrogates available for spatially allocating U.S. county-level emissions to the 36-km and 12-km grid cells used by the air quality model. As described in Section 3.4.2, an area-to-point approach overrides the use of surrogates for an airport refueling sources. Table 3-21 lists the codes and descriptions of the surrogates. Surrogate names and codes listed in *italics* are not directly assigned to any sources for the 2016 platforms, but they are sometimes used to gapfill other surrogates, or as an input for merging two surrogates to create a new surrogate that is used. The WRAP oil and gas surrogates used in 2016v2 and 2016v3 are not listed in Table 3-21 but are listed in Table 3-23.

Many surrogates were updated or newly developed for use in the 2014v7.0 platform (Adelman, 2016). They include the use of the 2011 National Land Cover Database (the previous platform used 2006) and development of various development density levels such as open, low, medium high and various combinations of these. These NLCD-based surrogates largely replaced the FEMA category (500 series) surrogates that were used in the 2011 platform. Additionally, onroad surrogates were developed using average annual daily traffic counts from the highway monitoring performance system (HPMS). Previously, the "activity" for the onroad surrogates was length of road miles. These and other surrogates are described in a reference (Adelman, 2016).

Several surrogates were updated or developed as new surrogates for the 2016 platforms:

- oil and gas surrogates represent activity during the year 2016;
- onroad spatial allocation uses surrogates that do not distinguish between urban and rural road types, correcting the issue arising in some counties due to the inconsistent urban and rural

definitions between MOVES, the activity data, and the surrogate data, and were further updated for the 2016 platform;

- spatial surrogates for onroadway sources use annual average daily traffic (AADT) for 2017;
- the surrogate used for truck stops was updated in 2019;
- a public schools surrogate (#508) was added in the 2016v2 platform;
- the use of 500 series surrogates (except for the new #508) were phased out; and
- rail surrogates were updated to fix some misallocated emissions in 2016v2.

The surrogates for the U.S. were mostly generated using the Surrogate Tools DB tool. The tool and documentation for the Surrogate Tools DB is available at https://www.cmascenter.org/surrogate_tools_db/.

Table 3-21. U.S. Surrogates available for the 2016 modeling platforms

Code	Surrogate Description	Code	Surrogate Description
N/A	Area-to-point approach (see 3.6.2)	*318*	*NLCD Pasture Land*
100	Population	319	NLCD Crop Land
110	*Housing*	320	NLCD Forest Land
131	*urban Housing*	321	NLCD Recreational Land
132	*Suburban Housing*	*340*	*NLCD Land*
134	*Rural Housing*	350	NLCD Water
137	*Housing Change*	508	Public Schools
140	*Housing Change and Population*	650	Refineries and Tank Farms
150	Residential Heating – Natural Gas	670	Spud Count – CBM Wells
160	*Residential Heating – Wood*	671	Spud Count – Gas Wells
170	Residential Heating – Distillate Oil	*672*	*Gas Production at Oil Wells*
180	Residential Heating – Coal	*673*	*Oil Production at CBM Wells*
190	Residential Heating – LP Gas	674	Unconventional Well Completion Counts
201	*Urban Restricted Road Miles*	676	Well Count – All Producing
202	Urban Restricted AADT	*677*	*Well Count – All Exploratory*
205	Extended Idle Locations	678	Completions at Gas Wells
211	*Rural Restricted Road Miles*	679	Completions at CBM Wells
212	*Rural Restricted AADT*	681	Spud Count – Oil Wells
221	*Urban Unrestricted Road Miles*	683	Produced Water at All Wells
222	*Urban Unrestricted AADT*	6831	Produced water at CBM wells
231	*Rural Unrestricted Road Miles*	6832	Produced water at gas wells
232	*Rural Unrestricted AADT*	6833	Produced water at oil wells
239	Total Road AADT	685	Completions at Oil Wells
240	Total Road Miles	*686*	*Completions at All Wells*
241	*Total Restricted Road Miles*	687	Feet Drilled at All Wells
242	All Restricted AADT	689	Gas Produced – Total
243	*Total Unrestricted Road Miles*	691	Well Counts - CBM Wells
244	All Unrestricted AADT	*692*	*Spud Count – All Wells*
258	Intercity Bus Terminals	693	Well Count – All Wells
259	Transit Bus Terminals	694	Oil Production at Oil Wells
260	*Total Railroad Miles*	695	Well Count – Oil Wells
261	NTAD Total Railroad Density	696	Gas Production at Gas Wells

Code	Surrogate Description	Code	Surrogate Description
271	NTAD Class 1 2 3 Railroad Density	*697*	*Oil Production at Gas Wells*
272	*NTAD Amtrak Railroad Density*	698	Well Count – Gas Wells
273	*NTAD Commuter Railroad Density*	699	Gas Production at CBM Wells
275	*ERTAC Rail Yards*	*710*	*Airport Points*
280	*Class 2 and 3 Railroad Miles*	711	Airport Areas
300	NLCD Low Intensity Development	801	Port Areas
301	*NLCD Med Intensity Development*	*802*	*Shipping Lanes*
302	*NLCD High Intensity Development*	*805*	*Offshore Shipping Area*
303	*NLCD Open Space*	*806*	*Offshore Shipping NEI2014 Activity*
304	NLCD Open + Low	*807*	*Navigable Waterway Miles*
305	NLCD Low + Med	*808*	*2013 Shipping Density*
306	NLCD Med + High	*820*	*Ports NEI2014 Activity*
307	NLCD All Development	850	Golf Courses
308	NLCD Low + Med + High	860	Mines
309	NLCD Open + Low + Med	*890*	*Commercial Timber*
310	NLCD Total Agriculture		

For the onroad sector, the on-network (RPD) emissions were spatially allocated differently from other off-network processes (e.g., RPV, RPP, RPHO). Surrogates for on-network processes are based on AADT data and off network processes (including the off-network idling included in RPHO) are based on land use surrogates as shown in Table 3-22. Emissions from the extended (i.e., overnight) idling of trucks were assigned to surrogate 205, which is based on locations of overnight truck parking spaces. The underlying data for this surrogate were updated during the development of the 2016 platforms to include additional data sources and corrections based on comments received and these updates were carried into this platform.

Table 3-22. Off-Network Mobile Source Surrogates

Source type	Source Type name	**Surrogate ID**	**Description**
11	Motorcycle	307	NLCD All Development
21	Passenger Car	307	NLCD All Development
31	Passenger Truck	307	NLCD All Development
32	Light Commercial Truck	308	NLCD Low + Med + High
41	Intercity Bus	306	NLCD Med + High
42	Transit Bus	259	Transit Bus Terminals
43	School Bus	508	Public Schools
51	Refuse Truck	306	NLCD Med + High
52	Single Unit Short-haul Truck	306	NLCD Med + High
53	Single Unit Long-haul Truck	306	NLCD Med + High
54	Motor Home	304	NLCD Open + Low
61	Combination Short-haul Truck	306	NLCD Med + High
62	Combination Long-haul Truck	306	NLCD Med + High

For the oil and gas sources in the np_oilgas sector, the spatial surrogates were updated to those shown in Table 3-23 using 2016 data consistent with what was used to develop the 2016v2 nonpoint oil and gas emissions. The primary activity data source used for the development of the oil and gas spatial surrogates was data from Drilling Info (DI) Desktop's HPDI database (Drilling Info, 2017). This database contains well-level location, production, and exploration statistics at the monthly level. Due to a proprietary agreement with DI Desktop, individual well locations and ancillary production cannot be made publicly available, but aggregated statistics are allowed. These data were supplemented with data from state Oil and Gas Commission (OGC) websites (Alaska, Arizona, Idaho, Illinois, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Nevada, Oregon and Pennsylvania, Tennessee). In cases when the desired surrogate parameter was not available (e.g., feet drilled), data for an alternative surrogate parameter (e.g., number of spudded wells) was downloaded and used. Under that methodology, both completion date and date of first production from HPDI were used to identify wells completed during 2016. In total, over 1 million unique wells were compiled from the above data sources. The wells cover 34 states and over 1,100 counties. (ERG, 2018).

Table 3-23. Spatial Surrogates for Oil and Gas Sources

Surrogate Code	Surrogate Description
670	Spud Count - CBM Wells
671	Spud Count - Gas Wells
672	Gas Production at Oil Wells
673	Oil Production at CBM Wells
674	Unconventional Well Completion Counts
676	Well Count - All Producing
677	Well Count - All Exploratory
678	Completions at Gas Wells
679	Completions at CBM Wells
681	Spud Count - Oil Wells
683	Produced Water at All Wells
685	Completions at Oil Wells
686	Completions at All Wells
687	Feet Drilled at All Wells
689	Gas Produced – Total
691	Well Counts - CBM Wells
692	Spud Count - All Wells
693	Well Count - All Wells
694	Oil Production at Oil Wells
695	Well Count - Oil Wells
696	Gas Production at Gas Wells
697	Oil Production at Gas Wells
698	Well Count - Gas Wells
699	Gas Production at CBM Wells
2688	WRAP Gas production at oil wells
2689	WRAP Gas production at all wells
2691	WRAP Well count - CBM wells
2693	WRAP Well count - all wells

Surrogate Code	Surrogate Description
2694	WRAP Oil production at oil wells
2695	WRAP Well count - oil wells
2696	WRAP Gas production at gas wells
2697	WRAP Oil production at gas wells
2698	WRAP Well count - gas wells
2699	WRAP Gas production at CBM wells
6831	Produced water at CBM wells
6832	Produced water at gas wells
6833	Produced water at oil wells

Not all of the available surrogates are used to spatially allocate sources in the modeling platform; that is, some surrogates shown in Table 3-21 were not assigned to any SCCs, although many of the "unused" surrogates are actually used to "gap fill" other surrogates that are used. When the source data for a surrogate has no values for a particular county, gap filling is used to provide values for the surrogate in those counties to ensure that no emissions are dropped when the spatial surrogates are applied to the emission inventories. Table 3-24 shows the CAP emissions (i.e., NH_3, NOx, $PM_{2.5}$, SO_2, and VOC) by sector assigned to each spatial surrogate.

Table 3-24. Selected 2016 CAP emissions by sector for U.S. Surrogates (short tons in 12US1)

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
afdust	240	Total Road Miles	0	0	303,187	0	0
afdust	304	NLCD Open + Low	0	0	826,942	0	0
afdust	306	NLCD Med + High	0	0	52,278	0	0
afdust	308	NLCD Low + Med + High	0	0	117,313	0	0
afdust	310	NLCD Total Agriculture	0	0	788,107	0	0
fertilizer	310	NLCD Total Agriculture	1,436,969	0	0	0	0
livestock	310	NLCD Total Agriculture	2,502,587	0	0	0	219,703
nonpt	100	Population	34,304	0	0	0	208
nonpt	150	Residential Heating - Natural Gas	33,550	204,371	4,041	1,365	12,055
nonpt	170	Residential Heating - Distillate Oil	1,531	30,031	3,284	11,510	1,039
nonpt	180	Residential Heating - Coal	1	3	1	3	3
nonpt	190	Residential Heating - LP Gas	98	31,061	163	712	1,181
nonpt	239	Total Road AADT	0	22	541	0	306,341
nonpt	244	All Unrestricted AADT	0	0	0	0	101,255
nonpt	271	NTAD Class 1 2 3 Railroad Density	0	0	0	0	2,203
nonpt	300	NLCD Low Intensity Development	4,823	19,093	94,548	2,882	72,599
nonpt	304	NLCD Open + Low	0	0	0	0	0
nonpt	306	NLCD Med + High	23,609	272,532	241,511	131,494	112,071
nonpt	307	NLCD All Development	85	25,798	110,610	8,256	69,262
nonpt	308	NLCD Low + Med + High	885	156,231	15,679	10,080	10,047
nonpt	310	NLCD Total Agriculture	0	0	38	0	0
nonpt	319	NLCD Crop Land	0	0	97	72	299

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
nonpt	320	NLCD Forest Land	3,953	68	273	0	279
nonpt	650	Refineries and Tank Farms	0	16	0	0	106,401
nonpt	711	Airport Areas	0	0	0	0	621
nonpt	801	Port Areas	0	0	0	0	6,730
nonroad	261	NTAD Total Railroad Density	3	2,154	227	1	426
nonroad	304	NLCD Open + Low	4	1,824	159	4	2,761
nonroad	305	NLCD Low + Med	94	15,985	3,832	119	115,955
nonroad	306	NLCD Med + High	305	183,591	11,839	328	94,299
nonroad	307	NLCD All Development	99	31,526	15,338	108	170,212
nonroad	308	NLCD Low + Med + High	498	338,083	28,486	241	51,957
nonroad	309	NLCD Open + Low + Med	119	21,334	1,256	151	45,828
nonroad	310	NLCD Total Agriculture	422	378,356	28,344	214	40,771
nonroad	320	NLCD Forest Land	15	5,910	699	9	3,944
nonroad	321	NLCD Recreational Land	83	11,616	6,517	89	246,560
nonroad	350	NLCD Water	188	115,168	5,952	232	355,808
nonroad	850	Golf Courses	13	2,001	117	16	5,647
nonroad	860	Mines	2	2,691	281	1	521
np_oilgas	670	Spud Count - CBM Wells	0	0	0	0	97
np_oilgas	671	Spud Count - Gas Wells	0	0	0	0	5,925
np_oilgas	674	Unconventional Well Completion Counts	20	25,363	819	20	1,307
np_oilgas	678	Completions at Gas Wells	0	5,348	136	2,976	18,333
np_oilgas	679	Completions at CBM Wells	0	2	0	80	415
np_oilgas	681	Spud Count - Oil Wells	0	0	0	0	14,747
np_oilgas	683	Produced Water at All Wells	0	0	0	0	13,876
np_oilgas	685	Completions at Oil Wells	0	259	0	888	29,548
np_oilgas	687	Feet Drilled at All Wells	0	46,704	1,478	44	2,661
np_oilgas	689	Gas Produced - Total	0	1,311	167	13	27,266
np_oilgas	691	Well Counts - CBM Wells	0	14,390	264	6	16,907
np_oilgas	694	Oil Production at Oil Wells	0	603	0	11,354	500,150
np_oilgas	695	Well Count - Oil Wells	0	113,164	2,562	74	456,274
np_oilgas	696	Gas Production at Gas Wells	0	1,539	0	0	299,205
np_oilgas	698	Well Count - Gas Wells	0	265,108	4,831	242	434,613
np_oilgas	699	Gas Production at CBM Wells	0	44	5	0	3,373
np_oilgas	2688	WRAP Gas production at oil wells	0	7,747	0	5,487	221,022
np_oilgas	2689	WRAP Gas production at all wells	0	26,598	780	1,133	28,306
np_oilgas	2691	WRAP Well count - CBM wells	0	225	19	0	1,524
np_oilgas	2693	WRAP Well count - all wells	0	17,239	460	17	1,768
np_oilgas	2694	WRAP Oil production at oil wells	0	35,144	543	18,367	110,330
np_oilgas	2695	WRAP Well count - oil wells	0	2,726	244	12	75,349
np_oilgas	2696	WRAP Gas production at gas wells	0	4,294	42	2	37,580
np_oilgas	2697	WRAP Oil production at gas wells	0	551	0	10	75,738
np_oilgas	2698	WRAP Well count - gas wells	0	8,160	513	14	120,726

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
np_oilgas	2699	WRAP Gas production at CBM wells	0	9,157	282	9	7,593
np_oilgas	6831	Produced water at CBM wells	0	0	0	0	966
np_oilgas	6832	Produced water at gas wells	0	0	0	0	5,742
np_oilgas	6833	Produced water at oil wells	0	0	0	0	21,502
np_solvents	100	Population	0	0	0	0	1,456,107
np_solvents	240	Total Road Miles	0	0	0	0	51,483
np_solvents	306	NLCD Med + High	33	27	300	1	493,575
np_solvents	307	NLCD All Development	24	6	19	5	403,847
np_solvents	308	NLCD Low + Med + High	0	0	129	0	29,372
np_solvents	310	NLCD Total Agriculture	0	0	0	0	172,111
onroad	205	Extended Idle Locations	318	41,411	1,094	17	5,733
onroad	242	All Restricted AADT	35,490	1,252,856	34,860	7,513	166,585
onroad	244	All Unrestricted AADT	67,069	1,885,571	65,860	16,707	459,731
onroad	259	Transit Bus Terminals	12	2,634	65	2	485
onroad	304	NLCD Open + Low	0	863	27	0	6,329
onroad	306	NLCD Med + High	860	96,718	4,861	85	22,594
onroad	307	NLCD All Development	3,768	237,388	6,263	1,544	620,009
onroad	308	NLCD Low + Med + High	230	25,814	534	94	35,326
onroad	508	Public Schools	15	2,396	126	2	687
rail	261	NTAD Total Railroad Density	13	33,389	996	15	1,647
rail	271	NTAD Class 1 2 3 Railroad Density	313	525,992	14,823	442	24,435
rwc	300	NLCD Low Intensity Development	16,940	35,198	308,965	8,247	334,158

For 36US3 modeling in the 2016 platforms, most U.S. emissions sectors were processed using 36-km spatial surrogates, and if applicable, 36-km meteorology. Exceptions include:

- For the onroad and onroad_ca_adj sectors, instead of running SMOKE-MOVES with 36km meteorological data, 36US3 emissions were aggregated from 12US1 by summing emissions from a 3x3 group of 12-km cells into a single 36-km cell. Differences in the 12-km and 36-km meteorology can introduce differences in onroad emissions, so this approach ensures that the 36-km and 12-km onroad emissions are consistent. However, this approach means that 36US3 onroad does not include emissions in Southeast Alaska; therefore, Alaska onroad emissions are included in a separate sector called onroad_nonconus that is processed for only the 36US3 domain. The 36US3 onroad_nonconus emissions are spatially allocated using 36-km surrogates and processed with 36-km meteorology.
- Similarly to onroad, because afdust emissions incorporate meteorologically-based adjustments, afdust_adj emissions for 36US3 were aggregated from 12US1 to ensure consistency in emissions between modeling domains. Again, similarly to onroad, this means 36US3 afdust does not include emissions in Southeast Alaska; therefore, Alaska afdust emissions are processed in a separate sector called afdust_ak_adj. The 36US3 afdust_ak_adj emissions are spatially allocated using 36-km surrogates and adjusted with 36-km meteorology.
- The ag and rwc sectors are processed using 36-km spatial surrogates, but using temporal profiles based on 12-km meteorology.

3.4.2 Allocation method for airport-related sources in the U.S.

There are numerous airport-related emission sources in the NEI, such as aircraft, airport ground support equipment, and jet refueling. The modeling platform includes the aircraft and airport ground support equipment emissions as point sources. For the modeling platform, the EPA used the SMOKE "area-to-point" approach for only jet refueling in the nonpt sector. The following SCCs use this approach: 2501080050 and 2501080100 (petroleum storage at airports), and 2810040000 (aircraft/rocket engine firing and testing). The ARTOPNT approach is described in detail in the 2002 platform documentation: https://www.epa.gov/sites/default/files/2020-10/documents/emissions_tsd_vol1_02-28-08.pdf. The ARTOPNT file that lists the nonpoint sources to locate using point data were unchanged from the 2005-based platform.

3.4.3 Surrogates for Canada and Mexico emission inventories

Spatial surrogates for allocating Mexico municipio level emissions were updated in the 2014v7.1 platform and carried forward into the 2016 platforms. For the 2016 beta (v7.2) platform, a set of Canada shapefiles were provided by ECCC along with cross references to spatially allocate the year 2015 Canadian emissions. Gridded surrogates were generated using the Surrogate Tool (previously referenced); Table 3-25 provides a list. For computational reasons, total roads (1263) were used instead of the unpaved rural road surrogate provided. The population surrogate for Mexico; surrogate code 11, uses 2015 population data at 1 km resolution and replaced the previous population surrogate code 10. The other surrogates for Mexico are circa 1999 and 2000 and were based on data obtained from the Sistema Municipal de Bases de Datos (SIMBAD) de INEGI and the Bases de datos del Censo Economico 1999. Most of the CAPs allocated to the Mexico and Canada surrogates are shown in Table 3-26.

Table 3-25. Canadian Spatial Surrogates

Code	Canadian Surrogate Description	Code	Description
100	Population	923	TOTAL INSTITUTIONAL AND GOVERNEMNT
101	total dwelling	924	Primary Industry
104	capped total dwelling	925	Manufacturing and Assembly
106	ALL_INDUST	926	Distribution and Retail (no petroleum)
113	Forestry and logging	927	Commercial Services
200	Urban Primary Road Miles	932	CANRAIL
210	Rural Primary Road Miles	940	PAVED ROADS NEW
211	Oil and Gas Extraction	945	Commercial Marine Vessels
212	Mining except oil and gas	946	Construction and mining
220	Urban Secondary Road Miles	948	Forest
221	Total Mining	951	Wood Consumption Percentage
222	Utilities	955	UNPAVED_ROADS_AND_TRAILS
230	Rural Secondary Road Miles	960	TOTBEEF
233	Total Land Development	970	TOTPOUL
240	capped population	980	TOTSWIN
308	Food manufacturing	990	TOTFERT
321	Wood product manufacturing	996	urban_area
323	Printing and related support activities	1251	OFFR_TOTFERT
324	Petroleum and coal products manufacturing	1252	OFFR_MINES

Code	Canadian Surrogate Description	Code	Description
326	Plastics and rubber products manufacturing	1253	OFFR Other Construction not Urban
327	Non-metallic mineral product manufacturing	1254	OFFR Commercial Services
331	Primary Metal Manufacturing	1255	OFFR Oil Sands Mines
350	Water	1256	OFFR Wood industries CANVEC
412	Petroleum product wholesaler-distributors	1257	OFFR UNPAVED ROADS RURAL
448	clothing and clothing accessories stores	1258	OFFR_Utilities
482	Rail transportation	1259	OFFR total dwelling
562	Waste management and remediation services	1260	OFFR_water
901	AIRPORT	1261	OFFR_ALL_INDUST
902	Military LTO	1262	OFFR Oil and Gas Extraction
903	Commercial LTO	1263	OFFR_ALLROADS
904	General Aviation LTO	1265	OFFR_CANRAIL
921	Commercial Fuel Combustion	9450	Commercial Marine Vessel Ports

Table 3-26. CAPs Allocated to Mexican and Canadian Spatial Surrogates (short tons in 36US3)

Sector	Code	Mexican / Canadian Surrogate Description	NH_3	NO_X	PM_{2_5}	SO_2	VOC
othafdust	106	CAN ALL_INDUST	0	0	609	0	0
othafdust	212	CAN Mining except oil and gas	0	0	3,142	0	0
othafdust	221	CAN Total Mining	0	0	17,315	0	0
othafdust	222	CAN Utilities	0	0	2,792	0	0
othafdust	940	CAN Paved Roads New	0	0	29,862	0	0
othafdust	955	CAN UNPAVED_ROADS_AND_TRAILS	0	0	426,511	0	0
othar	26	MEX Total Agriculture	560,091	82,958	48,439	1,987	18,052
othar	32	MEX Commercial Land	0	391	8,511	0	102,447
othar	34	MEX Industrial Land	164	4,244	4,135	11	102,903
othar	36	MEX Commercial plus Industrial Land	7	23,149	1,551	12	234,277
othar	40	MEX Residential (RES1-4)+Comercial+Industrial+Institutional+Government	4	90	424	12	105,233
othar	42	MEX Personal Repair (COM3)	0	0	0	0	25,999
othar	44	MEX Airports Area	0	16,295	216	1,183	6,834
othar	48	MEX Brick Kilns	0	2,778	55,550	5,031	1,352
othar	50	MEX Mobile sources - Border Crossing	3	71	2	0	57
othar	100	CAN Population	795	52	622	15	225
othar	101	CAN total dwelling	0	0	0	0	151,094
othar	104	CAN Capped Total Dwelling	361	31,746	2,335	2,671	1,650
othar	113	CAN Forestry and logging	152	1,818	9,778	37	5,140
othar	211	CAN Oil and Gas Extraction	1	43	433	74	2,122
othar	212	CAN Mining except oil and gas	0	0	11	0	0
othar	221	CAN Total Mining	0	0	293	0	0
othar	222	CAN Utilities	57	3,439	166	464	65
othar	308	CAN Food manufacturing	0	0	19,253	0	17,468
othar	321	CAN Wood product manufacturing	873	4,822	1,646	383	16,605

Sector	Code	Mexican / Canadian Surrogate Description	NH_3	NO_X	PM_{2_5}	SO_2	VOC
othar	323	CAN Printing and related support activities	0	0	0	0	11,778
othar	324	CAN Petroleum and coal products manufacturing	0	1,201	1,632	467	9,368
othar	326	CAN Plastics and rubber products manufacturing	0	0	0	0	24,270
othar	327	CAN Non-metallic mineral product manufacturing	0	0	6,541	0	0
othar	331	CAN Primary Metal Manufacturing	0	158	5,598	30	72
othar	412	CAN Petroleum product wholesaler-distributors	0	0	0	0	45,634
othar	448	CAN clothing and clothing accessories stores	0	0	0	0	143
othar	482	CAN Rail Transportation	1	4,106	89	1	258
othar	562	CAN Waste management and remediation services	247	1,981	2,747	2,508	9,654
othar	901	CAN Airport	0	108	10	0	11
othar	921	CAN Commercial Fuel Combustion	206	24,819	2,435	1,669	1,254
othar	923	CAN TOTAL INSTITUTIONAL AND GOVERNEMNT	0	0	0	0	14,847
othar	924	CAN Primary Industry	0	0	0	0	40,409
othar	925	CAN Manufacturing and Assembly	0	0	0	0	70,468
othar	926	CAN Distribution and Retail (no petroleum)	0	0	0	0	7,475
othar	927	CAN Commercial Services	0	0	0	0	32,096
othar	932	CAN CANRAIL	52	91,908	1,822	48	3,901
othar	946	CAN Construction and Mining	0	0	0	0	10,211
othar	951	CAN Wood Consumption Percentage	1,010	11,223	113,852	1,603	161,174
othar	990	CAN TOTFERT	49	4,185	276	6,834	160
othar	996	CAN urban_area	0	0	3,182	0	0
othar	1251	CAN OFFR_TOTFERT	79	65,830	4,646	54	6,266
othar	1252	CAN OFFR_MINES	1	905	67	1	134
othar	1253	CAN OFFR Other Construction not Urban	63	40,640	4,880	43	11,607
othar	1254	CAN OFFR Commercial Services	42	16,193	2,443	36	37,663
othar	1255	CAN OFFR Oil Sands Mines	23	12,478	410	12	1,330
othar	1256	CAN OFFR Wood industries CANVEC	8	3,180	288	6	1,102
othar	1257	CAN OFFR Unpaved Roads Rural	26	11,244	734	23	32,322
othar	1258	CAN OFFR_Utilities	8	4,471	229	6	930
othar	1259	CAN OFFR total dwelling	17	6,485	649	15	13,317
othar	1260	CAN OFFR_water	23	6,495	493	33	34,204
othar	1261	CAN OFFR_ALL_INDUST	4	5,654	185	2	1,105
othar	1262	CAN OFFR Oil and Gas Extraction	1	1,291	77	1	212
othar	1263	CAN OFFR_ALLROADS	3	1,826	185	2	494
othar	1265	CAN OFFR_CANRAIL	0	550	18	0	44
onroad_can	200	CAN Urban Primary Road Miles	1,742	84,596	2,810	367	8,888
onroad_can	210	CAN Rural Primary Road Miles	714	49,909	1,626	153	3,945
onroad_can	220	CAN Urban Secondary Road Miles	3,279	134,909	5,613	776	23,625
onroad_can	230	CAN Rural Secondary Road Miles	1,898	95,447	3,152	418	10,899
onroad_can	240	CAN Total Road Miles	346	63,465	1,500	88	117,123
onroad_mex	11	MEX 2015 Population	0	281,135	1,872	533	291,816
onroad_mex	22	MEX Total Road Miles	10,316	1,207,878	54,789	25,837	251,800
onroad_mex	36	MEX Commercial plus Industrial Land	0	7,971	142	29	9,187

3.5 Preparation of Emissions for the CAMx model

3.5.1 Development of CAMx Emissions for Standard CAMx Runs

To perform air quality modeling with the Comprehensive Air Quality Model with Extensions (CAMx model), the gridded hourly emissions output by the SMOKE model are output in the format needed by the CMAQ model, but must be converted to the format required by CAMx. For "regular" CAMx modeling (i.e., without two-way nesting), the CAMx conversion process consists of the following:

- Convert all emissions file formats from the I/O API NetCDF format used by CMAQ to the UAM format used by CAMx, including the merged, gridded low-level emissions files that include biogenics
- Shift hourly emissions files from the 25 hour format used by CMAQ to the averaged 24 hour format used by CAMx
- Rename and aggregate model species for CAMx
- Convert 3D wildland and agricultural fire emissions into CAMx point format
- Merge all inline point source emissions files together for each day, including layered fire emissions originally from SMOKE
- Add sea salt aerosol emissions to the converted, gridded low-level emissions files

Conversion of file formats from I/O API to CAMx (i.e., UAM) format is performed using a program called "cmaq2uam". In the CAMx conversion process, all SMOKE outputs are passed through this step first. Unlike CMAQ, the CAMx model does not have an inline biogenics option, and so for the purposes of CAMx modeling, emissions from SMOKE must include biogenic emissions.

One difference between CMAQ-ready emissions files and CAMx-ready emissions files involves hourly temporalization. A daily emissions file for CMAQ includes data for 25 hours, where the first hour is 0:00 GMT of a given day, and the last hour is 0:00 GMT of the following day. For the CAMx model, a daily emissions file must only include data for 24 hours, not 25. Furthermore, to match the hourly configuration expected by CAMx, each set of consecutive hourly timesteps from CMAQ-ready emissions files must be averaged. For example, the first hour of a CAMx-ready emissions file will equal the average of the first two hours from the corresponding CMAQ-ready emissions file, and the last (24^{th}) hour of a CAMx-ready emissions file will equal the average of the last two hours (24^{th} and 25^{th}) from the corresponding CMAQ-ready emissions file. This time conversion is incorporated into each step of the CAMx-ready emissions conversion process.

The CAMx model uses a slightly different version of the CB6 speciation mechanism than does the CMAQ model. SMOKE prepares emissions files for the CB6 mechanism used by the CMAQ model ("CB6-CMAQ"), and therefore, the emissions must be converted to the CB6 mechanism used by the CAMx model ("CB6-CAMx") during the CAMx conversion process. In addition to the mechanism differences, CMAQ and CAMx also occasionally use different species naming conventions. For CAMx modeling, we also create additional tracer species. A summary of the differences between CMAQ input species and CAMx input species for CB6 (VOC), AE6 (PM2.5), and other model species, is provided in Table 3-27. Each step of the CAMx-ready emissions conversion process includes conversion of CMAQ species to CAMx species using a species mapping table which includes the mappings in Table 3-27.

Table 3-27. Emission model species mappings for CMAQ and CAMx (for CB6R3AE7)

Inventory Pollutant	CMAQ Model Species	CAMx Model Species
Cl_2	CL2	CL2
HCl	HCL	HCL
CO	CO	CO
NO_X	NO	NO
	NO2	NO2
	HONO	HONO
SO_2	SO2	SO2
	SULF	SULF
NH_3	NH3	NH3
	NH3_FERT	n/a (not used in CAMx)
VOC	AACD	AACD
	ACET	ACET
	ALD2	ALD2
	ALDX	ALDX
	BENZ	BENZ and BNZA (duplicate species)
	CH4	CH4
	ETH	ETH
	ETHA	ETHA
	ETHY	ETHY
	ETOH	ETOH
	FACD	FACD
	FORM	FORM
	IOLE	IOLE
	ISOP	ISOP and ISP (duplicate species)
	IVOC	IVOA
	KET	KET
	MEOH	MEOH
	NAPH + XYLMN (sum)	XYL and XYLA (duplicate species)
	NVOL	n/a (not used in CAMx)
	OLE	OLE
	PAR	PAR
	PRPA	PRPA
	SESQ	SQT
	SOAALK	n/a (not used in CAMx)
	TERP + APIN (sum)	TERP and TRP (duplicate species)
	TOL	TOL and TOLA (duplicate species)
	UNR + NR (sum)	NR
PM_{10}	PMC	CPRM
$PM_{2.5}$	PEC	PEC
	PNO3	PNO3
	POC	POC
	PSO4	PSO4
	PAL	PAL
	PCA	PCA
	PCL	PCL
	PFE	PFE
	PK	PK

Inventory Pollutant	CMAQ Model Species	CAMx Model Species
	PH2O	PH2O
	PMG	PMG
	PMN	PMN
	PMOTHR	FPRM
	PNA	NA
	PNCOM	PNCOM
	PNH4	PNH4
	PSI	PSI
	PTI	PTI
	POC + PNCOM (sum)	POA[1]

[1] The POA species, which is the sum of POC and PNCOM, is passed to the CAMx model in addition to individual species POC and PNCOM.

One feature which is part of CMAQ and is not part of CAMx involves plume rise for fires. For CMAQ modeling, we process fire emissions through SMOKE as inline point sources, and plume rise for fires is calculated within CMAQ using parameters from the inline emissions files (heat flux, etc). This is similar to how non-fire point sources are handled, except that the fire parameters are used to calculate plume rise instead of traditional stack parameters. The CAMx model supports inline plume rise calculations using traditional stack parameters, but it does not support inline plume rise for fire sources. Therefore, for the purposes of CAMx modeling, we must have SMOKE calculate plume rise for fires using the Laypoint program. In this modeling platform, this must be done for the ptfire, ptfire_othna, and ptagfire sectors. To distinguish these layered fire emissions from inline fire emissions, layered fire emissions are processed with the sector names “ptfire-wild3D”, “ptfire-rx3D”, “ptfire_othna3D”, and “ptagfire3D”. When converting layered fire emissions files to CAMx format, stack parameters are added to the CAMx-ready fire emissions files to force the correct amount of fire emissions into each layer for each fire location.

CMAQ modeling uses one gridded low-level emissions file, plus multiple inline point source emissions files, per day. CAMx modeling also uses one gridded low-level emissions file per day - but instead of reading multiple inline point source emissions files at once, CAMx can only read a single point source file per day. Therefore, as part of the CAMx conversion process, all inline point source files are merged into a single “mrgpt” file per day using the program ptsmrg. The mrgpt file includes the layered fire emissions described in the previous paragraph, in addition to all non-fire elevated point sources from the cmv_c1c2, cmv_c3, othpt, ptegu, ptnonipm, and pt_oilgas sectors.

The remaining step in the CAMx emissions process is to generate sea salt aerosol emissions, which are distinct from ocean chlorine emissions. Sea salt emissions do not need to be included in CMAQ-ready emissions because they are calculated by the model, but they do need to be included in CAMx-ready emissions. After the merged low-level emissions are converted to CAMx format, sea salt emissions are generated using a program called “seasalt” and added to the low-level emissions. Sea salt emissions depend on meteorology, vary on a daily and hourly basis, and exist for model species sodium (NA), chlorine (PCL), sulfate (PSO4), dimethy sulfide (DMS), and gas phase bromine (SSBR) and chlorine (SSCL).

3.5.2 Development of CAMx Emissions for Source Apportionment CAMx Runs

The CAMx model supports source apportionment modeling for ozone and PM sources using techniques called Ozone Source Apportionment Technology (OSAT) and Particulate Matter Source Apportionment

Technology (PSAT). These source apportionment techniques allow emissions from different types of sources to be tracked through the CAMx model. Source apportionment model runs are most commonly performed using one-way nesting (i.e., the inner grid takes boundary information from the outer grid but the inner grid does not feed any concentration information back to the outer grid).

Source Apportionment modeling involves assigning tags to different categories of emissions. These tags can be applied by region (e.g., state), by emissions type (e.g., SCC or sector), or a combination of the two. For the Revised CSAPR Update study, emissions tagging was applied by state. All emissions from US states, except for biogenics, fires, and fugitive dust (afdust), were assigned a state-specific tag. Emissions from tribal lands are assigned a separate tag, as well as offshore emissions. Other tags include a tag for biogenics and afdust; a tag for all fires, both inside and outside the US; and a tag for all anthropogenic emissions from Canada and Mexico. A list of tags used in recent studies for state source apportionment modeling is provided in Table 3-28. State-level tags 2 through 51 exclude emissions from biogenics, fugitive dust, and fires, which are included in other tags.

For OSAT and PSAT modeling, all emissions must be input to CAMx in the form of a point source (mrgpt) file, including low level sources that are found in gridded files for regular CAMx runs. In addition, for any two-way nested modeling, all emissions must be input in a *single* mrgpt file, rather than separate mrgpt files for each of the domains. Note that fire emissions require special consideration in two-way nested model runs and for PSAT and OSAT modeling. That same consideration must be given to any sector in which emissions are being gridded by SMOKE.

There are two main approaches for tagging emissions for CAMx modeling. One approach is to tag emissions within SMOKE. Here, SMOKE will output tagged point source files (SGINLN files), which can then be converted to CAMx point source format with the tags applied by SMOKE carried forward into the CAMx inputs. The second approach is to, if necessary, depending on the nature of the tags, split sectors into multiple components by tag so that each sector corresponds to a single tag. Then, the gridded and/or point source format SMOKE outputs from those split sectors are converted to CAMx point source format, and then merged into the full mrgpt file, with the tags applied at that last step. In some situations, a mix of the two approaches is appropriate.

For ozone transport modeling runs, the first approach is used for most sectors, meaning tags are applied in SMOKE. The exceptions are when the entire sector receives only one tag, e.g.: afdust, beis, onroad_ca_adj, ptfire-rx, ptfire-wild, ptagfire, ptfire_othna, and all Canada and Mexico sectors. Afdust emissions are not tagged by state because the current tagging methodology does not support applying transportable fraction and meteorological adjustments to tagged emissions.

Once the individual sector tagging is complete, the point source files for all of the sectors are merged together to create the mrgpt file which includes all emissions, with the desired tags and appropriate resolution throughout the domain for OSAT or PSAT modeling.

Table 3-28. State tags for USA modeling

Tag	Emissions applied to tag
1	All biogenics (beis sector) and US fugitive dust (afdust sector)
2	Alabama
3	Arizona
4	Arkansas
5	California
6	Colorado
7	Connecticut

Tag	Emissions applied to tag
8	Delaware
9	District of Columbia
10	Florida
11	Georgia
12	Idaho
13	Illinois
14	Indiana
15	Iowa
16	Kansas
17	Kentucky
18	Louisiana
19	Maine
20	Maryland
21	Massachusetts
22	Michigan
23	Minnesota
24	Mississippi
25	Missouri
26	Montana
27	Nebraska
28	Nevada
29	New Hampshire
30	New Jersey
31	New Mexico

Tag	Emissions applied to tag
32	New York
33	North Carolina
34	North Dakota
35	Ohio
36	Oklahoma
37	Oregon
38	Pennsylvania
39	Rhode Island
40	South Carolina
41	South Dakota
42	Tennessee
43	Texas
44	Utah
45	Vermont
46	Virginia
47	Washington
48	West Virginia
49	Wisconsin
50	Wyoming
51	Tribal Data
52	Canada and Mexico (except fires)
53	Offshore
54	All fires from US, Canada, and Mexico, including ag fires

4 Development of Analytic Year Emissions

The emission inventories for analytic years of 2023 and 2026 have been developed using projection methods that are specific to the type of emissions source. Analytic year emissions are projected from the 2016 base case either by running models to estimate analytic year emissions from specific types of emission sources (e.g., EGUs, and onroad and nonroad mobile sources), or for other types of sources by adjusting the base year emissions according to the best estimate of changes expected to occur in the intervening years (e.g., non-EGU point and nonpoint sources). For some sectors, the same emissions are used in the base and analytic years, such as biogenic, all fire sectors, and fertilizer. Emissions for these sectors are held constant in future years because the 2016 meteorological data is used for the future year air quality model runs, and emissions for these sectors are highly correlated with meteorological conditions. For the remaining sectors, rules and specific legal obligations that go into effect in the intervening years, along with changes in activity for the sector, are considered when possible. For sectors that were projected, the methods used to project those sectors to 2023 and 2026 are summarized in Table 4-1. Detailed information about the changes in the 2016v3 platform is provided in the subsections that follow.

Table 4-1. Overview of projection methods for the future year cases

Platform Sector: ***abbreviation***	**Description of Projection Methods for Analytic Year Inventories**
EGU units: ***ptegu***	The Integrated Planning Model (IPM) outputs from the Updated Summer 2021 version of the IPM platform were used. For 2023, the 2023 IPM output year was used and for 2026 the 2025 output year was used. Emission inventory Flat Files for input to SMOKE were generated using post-processed IPM output data. **A list of included rules is provided in Section 4.1**.
Point source oil and gas: ***pt_oilgas***	First, known closures were applied to the 2016 pt_oilgas sources. Production-related sources were then grown from 2016 to 2021 using historic production data. The production-related sources were then grown to 2023 and 2026 based on growth factors derived from the Annual Energy Outlook (AEO) 2022 data for oil, natural gas, or a combination thereof. The grown emissions were then controlled to account for the impacts of New Source Performance Standards (NSPS) for oil and gas sources, process heaters, natural gas turbines, and reciprocating internal combustion engines (RICE). Some sources were held at 2018 or 2019 levels. WRAP future year inventories are used in all of the WRAP states except for New Mexico (CO, MT, ND, SD, UT and WY). The future year WRAP inventories are the same for all analytic years. New Mexico emissions are projected from 2016 along with the non-WRAP states.
Airports: ***airports***	Point source airport emissions were grown from 2016 to each analytic year using factors derived from the 2021 Terminal Area Forecast (TAF) released in June 2022 (see https://www.faa.gov/data_research/aviation/taf/). Corrections to emissions for ATL from the state of Georgia are included, as well as some corrections for specific airports in the state of Texas.

Platform Sector: *abbreviation*	Description of Projection Methods for Analytic Year Inventories
Remaining non-EGU point: ***ptnonipm***	2019 NEI data (EPA, 2022) were used for 2023 for most sources. Known closures were applied to ptnonipm sources. Closures were obtained from the Emission Inventory System (EIS) and also submitted by the states of Alabama, North Carolina, Ohio, Pennsylvania, and Virginia. Industrial emissions were grown according to factors derived from AEO2022 to reflect growth from 2023 onward. Rail yard emissions were grown using the same factors as line haul locomotives in the rail sector. Controls were applied to account for relevant NSPS for RICE, gas turbines, refineries (subpart Ja), and process heaters. The Boiler MACT is assumed to be fully implemented in 2016 except for North Carolina. Controls are reflected for the regional haze program in Arizona. Changes to ethanol plants and biorefineries are included. In 2016v3, additional closures were implemented, new sources were added based on 2019 NEI, and growth in MARAMA states was updated using MARAMA spreadsheets after incorporating AEO 2022 data. Railyards in California were updated with CARB data for 2023 and 2026. Point source solvents are based on 2019 NEI and projected to 2023 and 2026.
Category 1, 2 CMV: ***cmv_c1c2***	Category 1 and category 2 (C1C2) CMV emissions sources outside of California were projected to 2023 and 2026 based on factors from the Regulatory Impact Analysis (RIA) Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters per Cylinder. California emissions were projected based on factors provided by the state. Projection factors for Canada for 2026 were based on ECCC-provided 2023 and 2028 data interpolated to 2026. The 2023 and 2026 emissions are unchanged from 2016v2 except for the improved spatial allocation to counties.
Category 3 CMV: ***cmv_c3***	Category 3 (C3) CMV emissions were projected to 2023 and 2026 using an EPA report on projected bunker fuel demand that projects fuel consumption by region out to the year 2026. Bunker fuel usage was used as a surrogate for marine vessel activity. Factors based on the report were used for all pollutants except NOx. The NOx growth rates from the EPA C3 Regulatory Impact Assessment (RIA) were refactored to use the new bunker fuel usage growth rates. Assumptions of changes in fleet composition and emissions rates from the C3 RIA were preserved and applied to bunker fuel demand growth rates for 2023 and 2026 to arrive at the final growth rates. Projection factors for Canada for 2026 were based on ECCC-provided 2023 and 2028 data interpolated to 2026. The 2023 and 2026 emissions are unchanged from 2016v2 except for the improved spatial allocation to counties.
Locomotives: ***rail***	Passenger and freight locomotives were projected using separate factors. Freight emissions were computed for analytic years based on fuel use values for 2023 and 2026. Specifically, they were based on AEO2019 and 2020 freight rail energy use growth rate projections along with emission factors based on historic emissions trends that reflect the rate of market penetration of new locomotive engines.
Area fugitive dust: ***afdust, afdust_ak***	Paved road dust was grown to 2023 and 2026 levels based on the growth in VMT from 2016. The remainder of the sector including building construction, road construction, agricultural dust, and unpaved road dust was held constant at 2016 levels, except in the MARAMA region and NC where some factors were provided for categories other than paved roads. The projected emissions were reduced during modeling (as they are for the base year) according to a transport fraction computed using a new method for the 2016 beta platform and a meteorology-based zero-out that accounts for precipitation and snow/ice cover.

Platform Sector: *abbreviation*	Description of Projection Methods for Analytic Year Inventories
Livestock: *livestock*	Livestock were projected to 2023 and 2026 based on factors created from USDA National livestock inventory projections published in 2020 (https://www.ers.usda.gov/publications/pub-details/?pubid=92599). NC and NJ projections were state provided.
Nonpoint source oil and gas: *np_oilgas*	Exploration-related sources were baed on an average of 2017 through 2019 exploration data with NSPS controls applied, where applicable. Production-related emissions were initially projected to 2021 using historical data and then grown to 2023 and 2026 based on factors generated from AEO2022 reference case. Based on the SCC, factors related to oil, gas, or combined growth were used. Coalbed methane SCCs were projected independently. Controls were then applied to account for NSPS for oil and gas and RICE. WRAP future year inventories are used in seven WRAP states for 2023 and 2026 (except for NM, which is projected based on AEO).
Residential Wood Combustion: *rwc*	The 2016v3 emissions are the same as 2016v2, with the exception of Idaho, which uses the 2017 NEI for the base year emissions. RWC emissions were projected from 2016 to 2023 and 2026 based on growth and control assumptions compatible with EPA's 2011v6.3 platform, which accounts for growth, retirements, and NSPS, although implemented in the Mid-Atlantic Regional Air Management Association (MARAMA)'s growth tool. Factors provided by North Carolina were used for that state. RWC emissions in California, Oregon, and Washington were held constant at 2017 levels.
Solvents: *solvents*	Solvents are based on an updated method for 2016v3. The same projection and control factors were applied to solvent emissions as if these SCCs were in nonpt. Additional SCCs in the new inventory that correlate with human population were also projected. Solvent emissions associated with oil and gas activity were projected using the same projection factors as the oil and gas sectors. The 2016v1 NC and NJ nonpoint packets were used for 2023 and interpolated to 2026, and updated to apply to more SCCs. OTC controls for solvents were applied – both DE and NY provided new controls.
Remaining nonpoint: *nonpt*	Industrial emissions were grown according to factors derived from AEO2022 to reflect growth from 2021 onward. Data from earlier AEOs were used to derive factors for 2016 through 2021. Portions of the nonpt sector were grown using factors based on expected growth in human population. The MARAMA projection tool was used to project emissions to 2023 and 2026 after the AEO-based factors were updated to AEO2022. Factors provided by North Carolina and New Jersey were preserved. Controls were applied to reflect relevant NSPS rules (i.e., reciprocating internal combustion engines (RICE), natural gas turbines, and process heaters). Emissions were also reduced in 2016v2 and v3 to account for fuel sulfur rules in the mid-Atlantic and northeast not fully implemented by 2017. OTC controls for PFCs are included.
Nonroad: *nonroad*	Outside California and Texas and Texas, the MOVES3 model was run to create nonroad emissions for 2023 and 2026. The fuels used are specific to the analytic year, but the meteorological data represented the year 2016. EPA received new CARB data for analytic years for 2016v3. Texas nonroad emissions were provided by TCEQ for 2023 and 2028, and interpolated to 2026.

Platform Sector: *abbreviation*	Description of Projection Methods for Analytic Year Inventories
Onroad: ***onroad, onroad_nonconus***	Activity data for 2016 were backcast from the 2017 NEI then projected from 2016 to 2019 based on trends in FHWA VM-2 trends. Activity data were held flat from 2019 to 2021, and then projected from 2021 to 2023 and 2026 using factors derived from AEO2022. Where S/Ls provided activity data for 2023, those data were used. To create the emission factors, MOVES3 was run for the years 2023 and 2026 using 2016 meteorological data and fuels, but with age distributions projected to represent the analytic years and the remaining inputs consistent with those used in 2017. The analytic year activity data and emission factors were then combined using SMOKE-MOVES to produce the 2023 and 2026 emissions. Inspection and maintenance updates were included for NC and TN (this changed the representative county groupings for analytic years). **Section 4.3.2 describes the applicable rules that were considered when projecting onroad emissions**.
Onroad California: ***onroad_ca_adj***	CARB-provided emissions were used for California, but temporally allocated using MOVES3-based data. The 2016v3 platform uses new onroad emissions data provided by CARB for 2023 and 2026.
Other Area Fugitive dust sources not from the NEI: ***othafdust***	Othafdust emissions for the analytic years were provided by ECCC in 2016v1. Projection factors were derived from those 2023 and 2028 inventories and applied to the 2016v2 inventory. 2026 projection factors were interpolated from 2023 and 2028. No changes were made to 2023 or 2026 othafdust emissions in 2016v3. Mexico emissions are not included in this sector.
Other Point Fugitive dust sources not from the NEI: ***othptdust***	Wind erosion emissions were removed from the point fugitive dust inventories. Base year 2016 inventories with the rotated grid pattern removed were held flat for the analytic years, including the same transport fraction as the base year and the meteorology-based (precipitation and snow/ice cover) zero-out. No changes were made to 2023 or 2026 othptdust emissions between 2016v2 and 2016v3.
Other point sources not from the NEI: ***othpt***	Canada emissions for analytic years were provided by ECCC for use in 2016v1. Projection factors were derived from those 2023 and 2028 inventories and applied to the 2016v2 inventory. 2026 projection factors were interpolated from 2023 and 2028. No changes were made to othpt emissions between 2016v2 and 2016v3. Canada projections were applied by province-subclass where possible (i.e., where subclasses did not change from between platforms). For inventories where that was not possible, including airports and most stationary point sources except for oil and gas, projections were applied by province. For Mexico sources, Mexico's 2016 inventory was grown using to the analytic years 2023 and 2026, using state+pollutant factors based on the 2016v1 platform inventories.
Canada ag not from the NEI: ***canada_ag***	Reallocated base year emissions low-level agricultural sources that were originally developed on the rotated 10-km grid were projected to 2023 and 2026 using projection factors based on data provided by ECCC and applied by province, pollutant, and ECCC sub-class code. No changes were made to canada_ag emissions between 2016v2 and 2016v3.
Canada oil and gas 2D not from the NEI: ***canada_og2D***	Low-level point oil and gas sources from the ECCC 2016 emission inventory were projected to the analytic years based on province-subclass changes in the ECCC-provided data used for 2016v1. 2026 projection factors were interpolated from 2023 and 2028. No changes were made to canada_og2D emissions between 2016v2 and 2016v3.

Platform Sector: *abbreviation*	Description of Projection Methods for Analytic Year Inventories
Other non-NEI nonpoint and nonroad: ***othar***	Analytic year Canada nonpoint inventories were provided by ECCC for 2016v1. For Canadian nonroad sources, factors were provided from which the analytic year inventories could be derived. Projection factors were derived from those 2023 and 2028 inventories and applied to the 2016v2 inventory. 2026 projection factors were interpolated from 2023 and 2028. No changes were made to othar emissions between 2016v2 and 2016v3 in either Canada or Mexico. For Mexico nonpoint and nonroad sources, state-pollutant projection factors for 2023 and 2028 were calculated from the 2016v1 inventories, and then applied to the 2016v2 base year inventories. 2026 projection factors were interpolated from 2023 and 2028 in Mexico.
Other non-NEI onroad sources: ***onroad_can***	For Canadian mobile onroad sources, analytic year inventories were projected from 2016 to 2023 and 2026 using ECCC-provided projection data from v1 platform at the province and subclass (which is similar to SCC but not exactly) level, with 2026 interpolated from 2023 and 2028. No changes were made to onroad_can emissions between 2016v2 and 2016v3.
Other non-NEI onroad sources: ***onroad_mex***	Monthly onroad mobile inventories were developed at municipio resolution based runs of MOVES-Mexico for 2023, 2028, and 2035. 2023 was reused from the 2016v1 platform; 2026 was interpolated between 2023 and 2028 for 2016v2. No changes were made to onroad_mex emissions between 2016v2 and 2016v3.

4.1 EGU Point Source Projections (ptegu)

The 2023 and 2026 EGU emissions inventories used the outputs of the EPA's Updated Summer 2021 Reference Case of the Integrated Planning Model (IPM). IPM is a linear programming model that accounts for variables and information such as energy demand, planned unit retirements, and planned rules to forecast unit-level energy production and configurations. The following specific rules and regulations are included in the IPM v6 platform run (see the EPA's Updated Summer 2021 Reference Case web page for more details):

- The Revised Cross-State Air Pollution Rule (CSAPR) Update, a federal regulatory measure affecting EGU emissions from 12 states to address transport under the 2008 National Ambient Air Quality Standards (NAAQS) for ozone.
- The Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units through rate limits.
- The Mercury and Air Toxics Rule (MATS) finalized in 2011. MATS establishes National Emissions Standards for Hazardous Air Pollutants (NESHAP) for the "electric utility steam generating unit" source category.
- Current and existing state regulations, including current and existing Renewable Portfolio Standards and Clean Energy Standards as of the summer of 2021.
- The latest actions EPA has taken to implement the Regional Haze Regulations and Guidelines for Best Available Retrofit Technology (BART) Determinations Final Rule. The BART limits approved in these plans (as of summer 2020) that will be in place for EGUs are represented in the Updated Summer 2021 Reference Case.
- California AB 32 CO2 allowance price projections and the Regional Greenhouse Gas Initiative (RGGI) rule.
- Three non-air federal rules affecting EGUs: National Pollutant Discharge Elimination System- Final Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities, Hazardous, and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; and the Effluent Limitation Guidelines and Standards for the Steam Electric Power Generating Point Source Category.

IPM is run for a set of years, including 2023 and 2025 (the latter was used for the 2026 case). All inputs, outputs and full documentation of EPA's IPM v6 Updated Summer 2021 Reference Case and the associated NEEDS version from 08-03-2022 is available on the power sector modeling website (https://www.epa.gov/power-sector-modeling/supporting-documentation-2015-ozone-naaqs-actions). Some of the key parameters used in the IPM run are:

- Demand: AEO 2020
- Gas and Coal Market assumptions: updated as of Summer 2022
- Cost and performance of fossil generation technologies: AEO 2020
- Cost and performance of renewable energy generation technologies: NREL ATG 2020 (mid-case)
- Nuclear unit operational costs: AEO 2020 with some adjustments

- Environmental rules and regulations (on-the-books): Revised CSAPR, MATS, BART, CA AB 32, RGGI, various RPS and CES, non-air rules (Cooling Water Intake, ELC, CCR), State Rules and mandates as of Summer 2022 (see supplemental documentation on Updated Summer 2021 Reference Case page)
- Financial assumptions: 2016-2020 data, reflects tax credit extensions from Consolidated Appropriations Act of 2021
- Transmission: updated data with build options
- Retrofits: carbon capture and sequestration option for CCs
- Operating reserves (in select runs): Greater detail in representing interaction of load, wind, and solar, ensuring availability of quick response of resources at higher levels of RE penetration
- Fleet: Summer 2022 reference case NEEDS (NEEDS rev: 08-03-2022)

The EGU emissions are calculated for the inventory using the output of the IPM model for the forecast year. Units that are identified to have a primary fuel of landfill gas, fossil waste, non-fossil waste, residual fuel oil, or distillate fuel oil may be missing emissions values for certain pollutants in the generated inventory flat file. Units with missing emissions values are gapfilled using projected base year values. The projections are calculated using the ratio of the analytic year seasonal generation in the IPM parsed file and the base year seasonal generation at each unit for each fuel type in the unit as derived from the 2018 EIA-923 tables and the 2018 NEI. New controls identified at a unit in the IPM parsed file are accounted for with appropriate emissions reductions in the gapfill projection values. When base year unit-level generation data cannot be obtained no gapfill value is calculated for that unit.

Once IPM has been run, a process is performed to first parse the results to unit level and then to generate a flat file in a format that SMOKE can read. To accomplish this, a cross reference file is needed to map the NEEDS IDs to NEI IDs for facility and unit and for stack parameters. The cross reference file used for the 2016v3 IPM outputs was "*NEEDS_NEI_xref_2016_2019stk_13apr22.xlsx*" and incorporates information about unit and stack configurations from the 2019 NEI Point source inventory. The flat file that results from this process includes emissions for five summer months (May to September), four "shoulder" months (March, April, October, November) and three winter months (January, February, and December). The emissions from each of these "seasons" were placed into separate flat files so that SMOKE can preserve the total emissions within each season to the extent possible within rounding errors. Large EGUs in the IPM-derived flat file inventory are associated with hourly CEMS data for NOX and SO2 emissions values in the base year. To maintain a temporal pattern consistent with the 2016 base year, the NOX and SO2 values in the hourly CEMS inventories are projected to match the total seasonal emissions values in the analytic years as described in Section 3.3.2.2.

Combined cycle units produce some of their energy from process steam that turns a steam turbine. The IPM model assigns a fraction of the total combined cycle production to the steam turbine. When the emissions are calculated these steam units are assigned emissions values that come from the combustion portion of the process. In the base year NEI steam turbines are usually implicit to the total combined cycle unit. To achieve the proper plume rise for the total combined cycle emissions, the stack parameters for the steam turbine units were updated with the parameters from the combustion release point. Additionally, some units, such as landfill gas, may not be assigned a valid SCC in the initial flat file. The SCCs for these units were updated based on the base year SCC for the unit-fuel type.

The EGU sector NO_x emissions by state are listed in Table 4-2 for each of the 2016v3 cases. The state total emissions in this table may not exactly match the sum of the emissions for each state in the flat files for each season due to the process of apportioning seasonal total emissions to hours for input to SMOKE followed by summing the daily emissions back up to annual. However, any difference should be well within one percent of the state total emissions.

Table 4-2. EGU sector NOx emissions by State for the 2016v3 cases

State	2016gf	2023gf	2026gf
Alabama	28,835	13,389	11,987
Arizona	21,996	16,955	5,806
Arkansas	27,261	23,832	23,117
California	6,836	12,820	14,239
Colorado	30,243	15,324	13,584
Connecticut	4,062	2,772	2,411
Delaware	1,492	300	335
District of Columbia	NA	35	36
Florida	64,582	26,442	22,648
Georgia	29,359	29,119	9,594
Idaho	1,307	989	495
Illinois	32,180	13,598	8,753
Indiana	83,763	53,932	40,810
Iowa	22,950	23,989	22,944
Kansas	14,940	12,599	9,747
Kentucky	57,627	31,294	28,442
Louisiana	47,877	22,555	17,769
Maine	4,897	4,897	3,055
Maryland	10,449	2,895	2,510
Massachusetts	7,619	5,659	5,394
Michigan	43,330	24,830	22,606
Minnesota	21,646	19,609	11,961
Mississippi	16,407	9,913	3,811
Missouri	57,365	51,442	46,476
Montana	15,104	9,440	9,051
Nebraska	20,608	26,547	22,542
Nevada	3,898	8,367	2,500
New Hampshire	2,092	1,466	708
New Jersey	6,499	3,564	3,761
New Mexico	20,119	1,608	1,274
New York	18,972	11,108	10,199
North Carolina	35,329	38,958	26,228
North Dakota	38,220	33,180	30,907
Ohio	57,645	37,352	37,140

State	2016gf	2023gf	2026gf
Oklahoma	25,151	17,221	12,762
Oregon	4,005	1,262	2,042
Pennsylvania	83,540	31,181	11,850
Rhode Island	548	565	512
South Carolina	14,721	17,262	15,936
South Dakota	1,060	1,281	1,216
Tennessee	19,237	13,202	4,077
Texas	110,761	88,633	54,322
Tribal Areas	35,076	6,276	5,847
Utah	26,917	33,823	18,668
Vermont	256	267	27
Virginia	27,996	10,012	7,724
Washington	8,811	5,222	1,884
West Virginia	52,332	34,935	33,712
Wisconsin	16,209	14,232	6,337
Wyoming	36,098	22,729	13,987

4.2 Non-EGU Point and Nonpoint Sector Projections

To project all U.S. non-EGU stationary sources, facility/unit closures information and growth (PROJECTION) factors and/or controls were applied to certain categories within the afdust, ag, cmv, rail, nonpt, np_oilgas, ptnonipm, pt_oilgas and rwc platform sectors. Some facility or sub-facility-level closure information was also applied to the point sources. There are also a handful of situations where new inventories were generated for sources that did not exist in the NEI (e.g., biodiesel and cellulosic plants, yet-to-be constructed cement kilns). This subsection provides details on the data and projection methods used for the non-EGU point and nonpoint sectors.

Because the projection and control data are developed mostly independently from how the emissions modeling sectors are defined, this section is organized primarily by the type of projections data, with secondary consideration given to the emissions modeling sector (e.g., industrial source growth factors are applicable to four emissions modeling sectors). The rest of this section is organized in the order that the EPA uses the Control Strategy Tool (CoST) in combination with other methods to produce analytic year inventories: 1) for point sources, apply facility or sub-facility-level) closure information via CoST; 2) apply all PROJECTION packets via CoST (these contain multiplicative factors that could cause increases or decreases); 3) apply all percent reduction-based CONTROL packets via CoST; and 4) append any other analytic-year inventories not generated via CoST. This organization allows consolidation of the discussion of the emissions categories that are contained in multiple sectors, because the data and approaches used across the sectors are consistent and do not need to be repeated. Sector names associated with the CoST packets are provided in parentheses following the subsection titles. The projection and control factors applied by CoST to prepare the analytic year emissions are provided with other 2016v3 input data and reports on the 2016v3 FTP site.

4.2.1 Background on the Control Strategy Tool (CoST)

CoST is used to apply most non-EGU projection/growth factors, controls and facility/unit/stack-level closures to the 2016-based emissions modeling inventories to create analytic year inventories for the following sectors: afdust, airports, cmv, livestock, nonpt, np_oilgas, np_solvents, pt_oilgas, ptnonipm, rail, and rwc. Information about CoST and related data sets is available from https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-analysis-modelstools-air-pollution.

CoST allows the user to apply projection (growth) factors, controls and closures at various geographic and inventory key field resolutions. Using these CoST datasets, also called "packets" or "programs," supports the process of developing and quality assuring control assessments as well as creating SMOKE-ready analytic year (i.e., projected) inventories. Analytic year inventories are created for each emissions modeling sector by applying a CoST control strategy type called "Project future year inventory" and each strategy includes all base year 2016 inventories and applicable CoST packets. For reasons to be discussed later, some emissions modeling sectors may require multiple CoST strategies to account for the compounding of control programs that impact the same type of sources. There are also available linkages to existing and user-defined control measure databases and it is up to the user to determine how control strategies are developed and applied. The EPA typically creates individual CoST packets that represent specific intended purposes (e.g., aircraft projections for airports are in a separate PROJECTION packet from residential wood combustion sales/appliance turnover-based projections). CoST uses three packet types:

- CLOSURE: Closure packets are applied first in CoST. This packet can be used to zero-out (close) point source emissions at resolutions as broad as a facility to as specific as a release point. The EPA uses these types of packets for known post-2016 controls as well as information on closures provided by states on specific facilities, units or release points. This packet type is only used for the ptnonipm and pt_oilgas sectors.
- PROJECTION: Projection packets support the increase or decrease in emissions for virtually any geographic and/or inventory source level. Projection factors are applied as multiplicative factors to the base year emissions inventories prior to the application of any possible subsequent CONTROLs. A PROJECTION packet is necessary whenever emissions increase from the base year and is also desirable when information is based more on activity assumptions rather than on known control measures. The EPA uses PROJECTION packet(s) for many modeling sectors.
- CONTROL: Control packets are applied after any/all CLOSURE and PROJECTION packet entries. They support of similar level of specificity of geographic and/or inventory source level application as PROJECTION packets. Control factors are expressed as a percent reduction (0 – meaning no reduction, to 100 – meaning full reduction) and can be applied in addition to any pre-existing inventory control, or as a replacement control. For replacement controls, any controls specified in the inventory are first backed out prior to the application of a more-stringent replacement control).

These packets use comma-delimited formats and are stored as data sets within the Emissions Modeling Framework. As mentioned above, CoST first applies any/all CLOSURE information for point sources, then applies PROJECTION packet information, followed by CONTROL packets. A hierarchy is used by CoST to separately apply PROJECTION and CONTROL packets. In short, in a separate process for PROJECTION and CONTROL packets, more specific information is applied in lieu of less-specific information in ANY other packets. For example, a facility-level PROJECTION factor will be replaced by a unit-level, or facility and pollutant-level PROJECTION factor. It is important to note that this hierarchy does not apply between packet types (e.g., CONTROL packet entries are applied irrespective of PROJECTION packet hierarchies). A more specific example: a state/SCC-level PROJECTION factor will be applied before a stack/pollutant-level CONTROL factor that impacts the same inventory record. However, an inventory source that is subject to a CLOSURE packet record is removed from consideration of subsequent PROJECTION and CONTROL packets.

The implication for this hierarchy and intra-packet independence is important to understand and quality assure when creating future year strategies. For example, with consent decrees, settlements and state comments, the goal is typically to achieve a targeted reduction (from the base year inventory) or a targeted analytic-year emissions value. Therefore, controls due to consent decrees and state comments for specific cement kilns (expressed as CONTROL packet entries) need to be applied *instead of* (not in addition to) the more general approach of the PROJECTION packet entries for cement manufacturing. By processing CoST control strategies with PROJECTION and CONTROL packets separated by the type of broad measure/program, it is possible to show actual changes from the base year inventory to the future year inventory as a result of applying each packet.

Ultimately, CoST concatenates all PROJECTION packets into one PROJECTION dataset and uses a hierarchal matching approach to assign PROJECTION factors to the inventory. For example, a packet entry with Ranking=1 will supersede all other potential inventory matches from other packets. CoST then computes the projected emissions from all PROJECTION packet matches and then performs a similar routine for all CONTROL packets. Therefore, when summarizing "emissions reduced" from CONTROL packets, it is important to note that these reductions are not relative to the base year inventory, but rather to the intermediate inventory ***after*** application of any/all PROJECTION packet matches (and CLOSURES). A subset of the more than 70 hierarchy options is shown in Table 4-3, where the fields in the table are similar to those used in the SMOKE FF10 inventories. For example, "REGION_CD" is the county-state-county FIPS code (e.g., Harris county Texas is 48201) and "STATE" would be the 2-digit state FIPS code with three trailing zeroes (e.g., Texas is 48000).

Table 4-3. Subset of CoST Packet Matching Hierarchy

Rank	Matching Hierarchy	Inventory Type
1	REGION_CD, FACILITY_ID, UNIT_ID, REL_POINT_ID, PROCESS_ID, SCC, POLL	point
2	REGION_CD, FACILITY_ID, UNIT_ID, REL_POINT_ID, PROCESS_ID, POLL	point
3	REGION_CD, FACILITY_ID, UNIT_ID, REL_POINT_ID, POLL	point
4	REGION_CD, FACILITY_ID, UNIT_ID, POLL	point
5	REGION_CD, FACILITY_ID, SCC, POLL	point
6	REGION_CD, FACILITY_ID, POLL	point
7	REGION_CD, FACILITY_ID, UNIT_ID, REL_POINT_ID, PROCESS_ID, SCC	point
8	REGION_CD, FACILITY_ID, UNIT_ID, REL_POINT_ID, PROCESS_ID	point
9	REGION_CD, FACILITY_ID, UNIT_ID, REL_POINT_ID	point
10	REGION_CD, FACILITY_ID, UNIT_ID	point
11	REGION_CD, FACILITY_ID, SCC	point
12	REGION_CD, FACILITY_ID	point
13	REGION_CD, NAICS, SCC, POLL	point, nonpoint
14	REGION_CD, NAICS, POLL	point, nonpoint
15	STATE, NAICS, SCC, POLL	point, nonpoint
16	STATE, NAICS, POLL	point, nonpoint

Rank	Matching Hierarchy	Inventory Type
17	NAICS, SCC, POLL	point, nonpoint
18	NAICS, POLL	point, nonpoint
19	REGION_CD, NAICS, SCC	point, nonpoint
20	REGION_CD, NAICS	point, nonpoint
21	STATE, NAICS, SCC	point, nonpoint
22	STATE, NAICS	point, nonpoint
23	NAICS, SCC	point, nonpoint
24	NAICS	point, nonpoint
25	REGION_CD, SCC, POLL	point, nonpoint
26	STATE, SCC, POLL	point, nonpoint
27	SCC, POLL	point, nonpoint
28	REGION_CD, SCC	point, nonpoint
29	STATE, SCC	point, nonpoint
30	SCC	point, nonpoint
31	REGION_CD, POLL	point, nonpoint
32	REGION_CD	point, nonpoint
33	STATE, POLL	point, nonpoint
34	STATE	point, nonpoint
35	POLL	point, nonpoint

The contents of the controls, local adjustments and closures for the analytic year cases are described in the following subsections. Year-specific projection factors (PROJECTION packets) for each future year were used to create the future year cases, unless noted otherwise in the specific subsections. The contents of a few of these projection packets (and control reductions) are provided in the following subsections where feasible. However, most sectors used growth or control factors that varied geographically, and their contents could not be provided in the following sections (e.g., facilities and units subject to the Boiler MACT reconsideration has thousands of records). The remainder of Section 4.2 is divided into subsections that are summarized in Table 4-4. Note that independent analytic year inventories were used rather than projection or control packets for some sources.

Table 4-4. Summary of non-EGU stationary projections subsections

Subsection	Title	Sector(s)	Brief Description
4.2.2	CoST Plant CLOSURE packet	ptnonipm, pt_oilgas	All facility/unit/stack closures information, primarily from Emissions Inventory System (EIS), but also includes information from states and other organizations.
4.2.3	CoST PROJECTION packets	All	Introduces and summarizes national impacts of all CoST PROJECTION packets to the analytic year.
4.2.3.1	Fugitive dust growth	Afdust	PROJECTION packet: county-level resolution, primarily based on VMT growth.
4.2.3.2	Livestock population growth	Livestock	PROJECTION packet: national, by-animal type resolution, based on animal population projections.
4.2.3.3	Category 1 and 2 commercial marine vessels	cmv_c1c2	PROJECTION packet: Category 1 & 2: CMV uses SCC/poll for all states except Calif.

Subsection	Title	Sector(s)	Brief Description
4.2.3.4	Category 3 commercial marine vessels	cmv_c3	PROJECTION packet: Category 3: region-level by-pollutant, based on cumulative growth and control impacts from rulemaking.
4.2.3.5	Oil and gas and industrial source growth	nonpt, np_oilgas, ptnonipm, pt_oilgas	Several PROJECTION packets: varying geographic resolutions from state, county, and by-process/fuel-type applications. Data derived from AEO2022 were used for nonpt, ptnonipm, np_oilgas, and pt_oilgas sectors.
4.2.3.6	Non-IPM Point Sources	Ptnonipm	Several PROJECTION packets: specific projections from MARAMA region and states, AEO-based projection factors for industrial sources for non-MARAMA states.
4.2.3.7	Airport Sources	Ptnonipm	PROJECTION packet: by-airport for all direct matches to FAA Terminal Area Forecast data, with state-level factors for non-matching NEI airports.
4.2.3.8	Nonpoint sources	nonpt	Several PROJECTION packets: MARAMA states projection for Portable Fuel Containers and for all other nonpt sources. Non-MARAMA states projected with AEO-based factors for industrial sources. Evaporative Emissions from Finished Fuels projected using AEO-based factors. Human population used as growth for applicable sources.
4.2.3.9	Solvents	np_solvents	Several PROJECTION packets including population-based, and MARAMA state factors.
4.2.3.10	Residential wood combustion	rwc	PROJECTION packet: national with exceptions, based on appliance type sales growth estimates and retirement assumptions and impacts of recent NSPS.
4.2.4	CoST CONTROL packets	ptnonipm, nonpt, np_oilgas, pt_oilgas	Introduces and summarizes national impacts of all CoST CONTROL packets to the analytic year.
4.2.4.1	Oil and Gas NSPS	np_oilgas, pt_oilgas	CONTROL packets: reflect the impacts of the NSPS for oil and gas sources.
4.2.4.2	RICE NSPS	ptnonipm, nonpt, np_oilgas, pt_oilgas	CONTROL packets apply reductions for lean burn, rich burn, and combined engines for identified SCCs.
4.2.4.3	Fuel Sulfur Rules	ptnonipm, nonpt	CONTROL packet: updated by MARAMA, applies reductions to specific units in ten states.
4.2.4.4	Natural Gas Turbines NOx NSPS	ptnonipm	CONTROL packets apply NOx emission reductions established by the NSPS for turbines.
4.2.4.5	Process Heaters NOx NSPS	ptnonipm	CONTROL packet: applies NOx emission limits established by the NSPS for process heaters.
4.2.4.6	Ozone Transport Commission Rules	nonpt, np_solvents	CONTROL packets reflecting rules for solvents and portable fuel containers.

4.2.2 CoST Plant CLOSURE Packet (ptnonipm, pt_oilgas)

Packets:

CLOSURES_2016v3_platform_ptnonipm_26aug2022_nf_v1

The CLOSURES packet contains facility, unit and stack-level closure information derived from an Emissions Inventory System (EIS) unit-level report from June 9, 2021, with closure status equal to "PS" (permanent shutdown; i.e., post-2016 permanent facility/unit shutdowns known in EIS as of the date of the report). For 2016v3, additional closures were added and those are cumulative with the closures in 2016v2. Any data provided by commenters for closures were updated to match the SMOKE FF10 inventory key fields, with all duplicates removed, and a single CoST packet was generated. These changes impact sources in the ptnonipm and pt_oilgas sectors. Additional closures provided in comments on the 2016v2 inventories were incorporated in the 2016v3 platform for multiple states including Ohio, Wisconsin, North Carolina, and North Dakota. The spreadsheet in the reports folder on the 2016v3 FTP site called *point_controls_packet_2016v3.xlsx* lists all closures, while the spreadsheet called *ptnonipm_19_2023gf_new_closures.xlsx* available lists the closures there were new in 2016v3 and their impacts. The cumulative reduction in emissions for ptnonipm and pt_oilgas are shown in Table 4-5. The amount of emission reductions are from 2019 emissions levels, not 2016 emissions, because the closures were applied to the 2019 inventory that was used as the starting point for the projection to 2023.

Table 4-5. Reductions from all facility/unit/stack-level closures in 2016v3 from 2019 emissions levels

Pollutant	Ptnonipm	pt_oilgas
CO	5,428	1,343
NH3	631	0
NOX	6,652	2,846
PM10	3,185	49
PM2.5	2,240	49
SO2	6,461	178
VOC	5,040	388

4.2.3 CoST PROJECTION Packets (afdust, airports, cmv, livestock, nonpt, np_oilgas, np_solvents, ptnonipm, pt_oilgas, rail, rwc)

For point inventories, after the application of any/all CLOSURE packet information, the next step CoST performs when running a control strategy is the application of all PROJECTION packets. Regardless of inventory type (point or nonpoint), the PROJECTION packets are applied prior to the CONTROL packets. For several emissions modeling sectors (i.e., airports, np_oilgas, pt_oilgas), there is only one PROJECTION packet applied for each analytic year. For all other sectors, there are several different sources of projection data and as a result there are multiple PROJECTION packets that are concatenated by CoST during a control strategy run and quality-assured regarding duplicates and applicability to the inventories in the CoST strategy. Similarly, CONTROL packets are kept in distinct datasets for different control programs. Having the PROJECTION (and CONTROL) packets separated into "key" projection and control programs allows for quick summaries of these distinct control programs.

For the 2016v1 platform MARAMA provided PROJECTION and CONTROL packets for years 2023 and 2028 for states including: Connecticut, Delaware, Maryland, Massachusetts, New Hampshire, New York, New Jersey, North Carolina, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, Maine, and the District of Columbia.   MARAMA provided pt_oilgas and np_oilgas packets only for Rhode Island, Maryland and Massachusetts. For 2016v2, new spreadsheets of projection factors were provided that facilitated the incorporation of data from the AEO 2022 and other surrogate data for projection factors. The new spreadsheets also to reflect sources affected by the Pennsylvania Reasonably Available Control Technology (RACT) II including 2023 emissions for one Pennsylvania facility (Anchor Hocking LLC, Monaca Plant) affected by the rule. For that facility, emissions values were swapped in after applying all other projections and controls. For states not covered by the MARAMA packets, projection factors were developed using nationally available data and methods.

4.2.3.1 Fugitive dust growth (afdust)

Packets:

Projection_2016_2023_afdust_version1_platform_MARAMA_15jul21_v2
Projection_2016_2023_afdust_version1_platform_NJ_20aug2021_v1
Projection_2016_2023_afdust_version3_platform_national_03aug2022_v0
Projection_2016_2023_all_nonpoint_version1_platform_NC_24jun2021_nf_v5
Projection_2016_2026_afdust_version1_platform_MARAMA_nopavedroads_noNCNJ_15jul2021_v0
Projection_2016_2026_afdust_version1_platform_NJ_nopavedroads_20jul2021_v0
Projection_2016_2026_afdust_version3_platform_national_30aug2022_v0
Projection_2016_2026_all_nonpoint_version2_platform_NC_30aug2022_nf_v2

MARAMA States

MARAMA provided a spreadsheet tool that could be used to compute projection factors for their states to project 2016 afdust emissions to analytic years 2023 and 2026. These county-specific projection factors impacted paved roads (SCC 2294000000), residential construction dust (SCC 2311010000), industrial/commercial/institutional construction dust (SCC 2311020000), road construction dust (SCC 2311030000), dust from mining and quarrying (SCC 2325000000), agricultural crop tilling dust (SCC 2801000003), and agricultural dust kick-up from beef cattle hooves (SCC 2805001000). Other afdust emissions, including unpaved road dust emissions, were held constant in analytic year projections. North Carolina and New Jersey provided their own packets for this sector for 2023 and 2028, which were interpolated to 2026. For paved roads, new VMT-based projection factors based on 2016v3 VMT were used in place of projection factors provided by MARAMA, NC, and NJ for all years, since their factors were based on older VMT.

Non-MARAMA States

For paved roads (SCC 2294000000), the 2016 afdust emissions were projected to analytic years 2023 and 2026 based on differences in county total VMT:

$$\text{Analytic year afdust paved roads} = \text{2016 afdust paved roads} * (\text{Analytic year county total VMT}) / (\text{2016 county total VMT})$$

The VMT projections are described in the onroad section. Paved road dust emissions were projected this way in all states, including MARAMA states.

In non-MARAMA states, all emissions other than paved roads are held constant in the analytic year projections. The impacts of the projections are shown in Table 4-6.

Table 4-6. Increase in total afdust $PM_{2.5}$ emissions from projections in 2016v3

2016 Emissions	2023 Emissions	percent Increase 2023	2026 Emissions	percent Increase 2026
2,254,168	2,296,234	1.87%	2,314,652	2.68%

4.2.3.2 Livestock population growth (livestock)

Packets:

Projection_2016_2023_all_nonpoint_version1_platform_NC_24jun2021_nf_v5
Projection_2016_2026_all_nonpoint_version2_platform_NC_19jul2021_nf_v1
Projection_2017_2023_ag_livestock_version3_platform_05aug2022_v0
Projection_2017_2023_ag_version1_platform_NJ_20aug2021_v1
Projection_2017_2026_ag_livestock_version3_platform_30aug2022_v0
Projection_2017_2026_livestock_version2_platform_NJ_16jul2021_v0

The 2017NEI livestock emissions were projected to year 2023 and 2026 using projection factors created from USDA National livestock inventory projections published in February 2022 (https://www.ers.usda.gov/publications/pub-details/?pubid=103309) and are shown in Table 4-7. For emission projections to 2023, a ratio was created between animal inventory counts for 2023 and 2017 to create a projection factor. This process was completed for the animal categories of beef, dairy, broilers, layers, turkeys, and swine. The projection factor was then applied to the 2017NEI base emissions for the specific animal type to estimate 2023 NH_3 and VOC emissions. For emission projections to 2026, the equivalent method was used to develop and apply the factors. New Jersey (NJ) provided NJ-specific projection factors that were used to grow livestock waste emissions from 2017 to 2023 and 2028. The factors were interpolated to obtain factors for 2026. North Carolina (NC) provided NC-specific projection factors that used a 2016-based projection; therefore, NC's livestock waste emissions are projected from the 2016 base year emissions to the years 2023 and 2026. As in New Jersey, North Carolina provided projection factors for 2023 and 2028, which were interpolated to 2026.

Table 4-7. National projection factors for livestock: 2017 to 2023 and 2026

Animal	2017-to-2023	2017-to-2026
Beef	-1.79%	-0.32%
Swine	+5.73%	+6.93%
Broilers	+9.06%	+12.97%
Turkeys	-0.85%	+2.10%
Layers	+4.45%	+9.67%
Dairy	-1.06%	-0.85%

4.2.3.3 Category 1, Category 2 Commercial Marine Vessels (cmv_c1c2)

Packets:

Projection_2016_2023_cmv_c1c2_version1_platform_04oct2019_v1
Projection_2016_2023_cmv_Canada_version1_platform_24sep2019_v0
Projection_2016_2026_cmv_c1c2_version2_platform_14jul2021_v0
Projection_2016_2026_cmv_Canada_version2_platform_15jul2021_v0

Category 1 and category 2 (C1C2) CMV emissions sources outside of California were projected to 2023 and 2026 based on factors derived from the Regulatory Impact Analysis (RIA) Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters per Cylinder (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-air-pollution-locomotive). The 2023 cmv_c1c2 emissions for 2016v3 are based on the same raw data as the 2016v1 and 2016v2 emissions, but an improved method to spatially allocate the emissions to counties was used. The projection factors to obtain the 2026 emissions are equivalent to interpolating 2016v1 emissions projection factors between 2023 and 2028. California emissions were projected based on factors provided by the state. Table 4-8 lists the pollutant-specific projection factors to 2023 and 2028 that were used for cmv_c1c2 sources outside of California. California sources were projected to 2023 and 2028 using the factors in Table 4-9, which are based on data provided by CARB.

Projection factors for Canada for 2026 were based on ECCC-provided 2023 and 2028 data interpolated to 2026.

Table 4-8. National projection factors for cmv_c1c2

Pollutant	2016-to-2023 (%)	2016-to-2026 (%)
CO	-1.3%	-0.4%
NOX	-29.3%	-39.0%
PM10	-28.3%	-37.8%
PM2.5	-28.3%	-37.8%
SO2	-65.3%	-65.7%
VOC	-31.5%	-42.0%

Table 4-9. California projection factors for cmv_c1c2

Pollutant	2016-to-2023 (%)	2016-to-2026 (%)
CO	+20.1%	+23.2%
NOX	-15.0%	-16.6%
PM10	-29.9%	-32.1%
PM2.5	-29.9%	-32.1%
SO2	+24.1%	+38.9%
VOC	+1.5%	+1.7%

4.2.3.4 Category 3 Commercial Marine Vessels (cmv_c3)

Packets:

Projection_2016_2023_cmv_c3_version1_platform_04oct2019_v2_Mexico[36]
Projection_2016_2023_cmv_c3_version1_platform_24sep2019_v1
Projection_2016_2023_cmv_Canada_version1_platform_24sep2019_v0
Projection_2016_2026_cmv_c3_version2_platform_15jul2021_v0
Projection_2016_2026_cmv_Canada_version2_platform_15jul2021_v0

Growth rates for cmv_c3 emissions from 2016 to 2023, and 2026 were projected using an EPA report on projected bunker fuel demand. Bunker fuel usage was used as a surrogate for marine vessel activity. Bunker fuel usage was used as a surrogate for marine vessel activity. Factors based on the report were used for all pollutants except NOx.

Growth factors for NOx emissions were handled separately to account for the phase in of Tier 3 vessel engines. To estimate these emissions, the NOx growth rates from the EPA C3 Regulatory Impact Assessment (RIA)[37] were refactored to use the new bunker fuel usage growth rates. The assumptions of changes in fleet composition and emissions rates from the C3 RIA were preserved and applied to the new bunker fuel demand growth rates for 2023 and 2026 to arrive at the final growth rates. The Category 3 marine diesel engines Clean Air Act and International Maritime Organization standards from April, 2010 (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-new-marine-compression-0) were also considered when computing the emissions.

The 2023 cmv_c3 emissions for 2016v3 are based on the same raw data as the 2016v1 and 2016v2 emissions, but an improved method to spatially allocate the emissions to counties using 1-hour AIS locations rather than grid cell centroids was used. The 2026 projection factors are equivalent to interpolating the 2016v1 emissions between 2023 and 2028. Projection factors for Canada for 2026 were based on ECCC-provided 2023 and 2028 data interpolated to 2026.

The 2023 and 2026 projection factors are shown in Table 4-10. Some regions for which 2016 projection factors were available did not have 2023 or 2026 projection factors specific to that region, so factors from another region were used as follows:

- Alaska was projected using North Pacific factors.
- Hawaii was projected using South Pacific factors.
- Puerto Rico and Virgin Islands were projected using Gulf Coast factors.
- Emissions outside Federal Waters (FIPS 98) were projected using the factors given in Table 4-10 for the region "Other".
- California was projected using a separate set of state-wide projection factors based on CMV emissions data provided by the California Air Resources Board (CARB). These factors are shown in Table 4-11

[36] 2023 has a Mexico packet is because the Mexico CMV inventory covers some ports, but no offshore underway. This inventory has emissions in the 36US3 domain only, not 12US1 and was not projected to 2026 or 2032.
[37] https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1005ZGH.TXT.

Table 4-10. 2016-to-2023 and 2016-to-2026 CMV C3 projection factors outside of California

Region	2016-to-2023 NOX	2016-to-2023 other pollutants	2016-to-2026 NOX	2016-to-2026 other pollutants
US East Coast	-6.1%	+27.7%	-6.9%	+41.4%
US South Pacific (ex. California)	-24.8%	+20.9%	-30.3%	+36.6%
US North Pacific	-3.4%	+22.6%	-3.8%	+34.6%
US Gulf	-6.9%	+20.8%	-10.2%	+29.8%
US Great Lakes	+8.7%	+14.6%	+15.4%	+22.7%
Other	+23.1%	+23.1%	+35.0%	+35.0%

Non-Federal Waters	2016-to-2023	2016-to-2026
SO2	-77.2%	-75.0%
PM (main engines)	-36.1%	-29.9%
PM (aux. engines)	-39.7%	-33.9%
Other pollutants	+23.1%	+35.0%

Table 4-11. 2016-to-2023 and 2016-to-2026 CMV C3 projection factors for California

Pollutant	2016-to-2023	2016-to-2026
CO	1.180	1.276
Nox	1.156	1.259
PM_{10} / $PM_{2.5}$	1.205	1.311
SO_2	1.183	1.272
VOC	1.242	1.373

4.2.3.5 Oil and Gas Sources (pt_oilgas, np_oilgas)

Packets:

Projection_2016_2023_np_oilgas_version3_platform_24aug2022_v0
Projection_2016_2023_pt_oilgas_version3_platform_24aug2022_v0
Projection_2016_2026_np_oilgas_version3_platform_24aug2022_v0
Projection_2016_2026_pt_oilgas_version3_platform_24aug2022_v0

Year 2028 inventories for seven of the WRAP states were provided by   The details about these non-point and point source oil and gas data can be found here: http://www.wrapair2.org/pdf/WRAP_OGWG_2028_OTB_RevFinalReport_05March2020.pdf (WRAP / Ramboll, 2020).   As provided, this WRAP data for np_oilgas and pt_oilgas were intended to be the same for all analytic years. Therefore emissions in 2023 are the same as in 2026 except that New Mexico np_oilgas emissions were projected and controlled using the EPA methodology of using historical production data from the state of New Mexico[38] along with AEO2022-based forecast information.

For areas outside of the WRAP states, analytic year projections for the 2016v3 platform were generated for point oil and gas sources for years 2023 and 2026. These projections consisted of three components: (1) applying facility closures to the pt_oilgas sector using the CoST CLOSURE packet; (2) using historical and/or forecast activity data to generate analytic-year emissions before applicable control

[38] https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Reporting/Production/CountyProductionInjectionSummary.aspx

technologies are applied using the CoST PROJECTION packet; and (3) estimating impacts of applicable control technologies on analytic-year emissions using the CoST CONTROL packet. Applying the CLOSURE packet to the pt_oilgas sector resulted in small emissions changes to the national summary shown in Table 4-5. Note that the closures applied for the years 2023 and 2026 are the same.

For pt_oilgas growth to 2023 and 2026, the oil and gas sources were separated into production-related and exploration-related sources by NAICS and SCC. These sources were further subdivided by fuel-type and by NAICS and SCC into either OIL, natural gas (NGAS), BOTH (where oil or natural gas fuels are possible), or coal-bed methane (CBM). The next two subsections describe the growth component of the process.

For np_oilgas growth to 2023 and 2026, oil and gas sources were separated into production-related and exploration-related sources. These sources were further separated into oil, natural gas or coal bed methane production related.

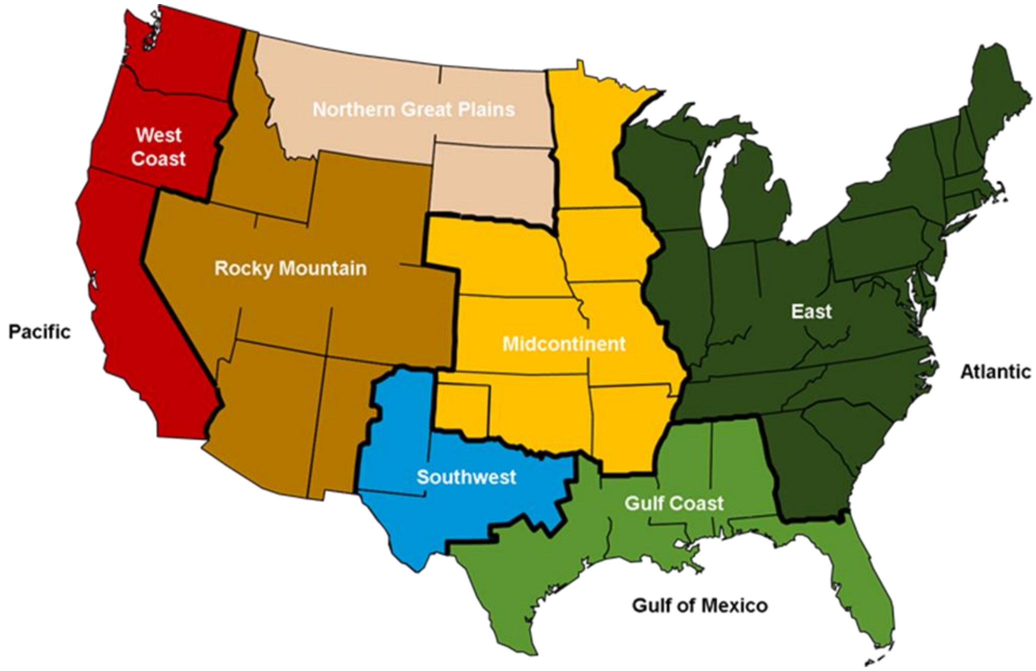
Production-related Sources (pt_oilgas, np_oilgas)

The growth factors for the production-related NAICS-SCC combinations were generated in a two-step process. The first step used historical production data at the state-level to get state-level short-term trends or factors from 2016 to year 2021. These historical data were acquired from EIA from the following links:

- Historical Natural Gas: http://www.eia.gov/dnav/ng/ng_sum_lsum_a_epg0_fgw_mmcf_a.htm
- Historical Crude Oil: http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm
- Historical CBM: https://www.eia.gov/dnav/ng/ng_prod_coalbed_s1_a.htm

The second step involved using the Annual Energy Outlook (AEO) 2022 reference case for the Lower 48 forecast production tables to project from the year 2021 to the years of 2023 and 2026. Specifically, *AEO 2022 Table 58 "Lower 48 Crude Oil Production and Wellhead Prices by Supply Region"* and *AEO 2022 Table 59 "Lower 48 Natural Gas Production and Supply Prices by Supply Region"* were used in this projection process. The AEO2022 forecast production is supplied for each EIA Oil and Gas Supply region shown in Figure 4-1.

Figure 4-1. EIA Oil and Gas Supply Regions as of AEO2022



The result of this second step is a growth factor for each Supply Region from 2021 to 2023 and from 2021 to 2026. A Supply Region mapping to FIPS cross-walk was developed so the regional growth factors could be applied for each FIPS (for pt_oilgas) or to the county-level np_oilgas inventories. Note that portions of Texas are in three different Supply Regions and portions of New Mexico are in two different supply regions. The state-level historical factor (from 2016 to 2021) was then multiplied by the Supply Region factor (from 2021 to the analytic years) to produce a state-level or FIPS-level factor to grow from 2016 to 2023 and from 2016 to 2026. This process was done using crude production forecast information to generate a factor to apply to oil-production related SCCs or NAICS-SCC combinations and it was also done using natural gas production forecast information to generate a factor to apply to natural gas-production related NAICS-SCC combinations. For the NAICS-SCC combinations that are designated "BOTH" the average of the oil-production and natural-gas production factors was calculated and applied to these specific combinations.

The state of Texas provided specific comments on the growth of production-related point sources. Texas provided updated basin specific production for 2016 and 2021 to allow for a better calculation of the estimated growth for this three-year period (http://webapps.rrc.texas.gov/PDQ/generalReportAction.do). The AEO2022 was used as described above for the three AEO Oil and Gas Supply Regions that include Texas counties to grow from 2021 to 2023 and 2026. However, Texas only wanted these growth factors applied to sources in the Permian and Eagle Ford basins and the oil and gas production point sources in the other basins in Texas were not grown.

The state of New Mexico is broken up into two AEO Oil and Gas Supply Regions. County production data for New Mexico was obtained from their state website (https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Reporting/Production/CountyProductionInjectionSummary.aspx) so that a better estimate of growth from 2016 to 2021 for the AEO Supply Regions in New Mexico could be calculated.

Transmission-related Sources (pt_oilgas)

Projection factors for transmissions-related sources were generated using the same AEO2022 tables used for production sources. These growth factors sources were developed solely using AEO 2022 data for the entire lower 48 states (one national factor for oil transmission and one national factor for natural gas transmission). The WRAP future year inventory was used for 6 of the 7 states in that inventory. The exception was New Mexico where the projection method described in this section was used.

Exploration-related Sources (np_oilgas)

Due to the year 2016 being a low exploration activity year when compared to exploration activity in other recent years, years 2017 through 2019 exploration emissions were generated using the 2017NEI version of the Oil and Gas Tool. Table 4-12 provides a high-level national summary of the emissions data for the three years. This three-year average (2017-2019) emissions data were used in 2016v3 because they reflected the most recent average of exploration activity and emissions. These averaged emissions were used for both the 2023 and 2026 analytic years. Note that CoST was not used to perform this projection step for exploration sources.

Table 4-12. Year 2017-2019 high-level summary of national oil and gas exploration emissions

	2017 emissions (tons)	2018 emissions (tons)	2019 emissions (tons)	Three Year avg (2017-2019) (tons)
NOX	73,992	123,908	108,957	102,285
VOC	118,004	136,916	106,505	120,474

Projection overrides (pt_oilgas)

A draft set of projected point oil and gas emissions were reviewed and compared to recent emissions data from 2018 and 2019. In cases where the recent and projected emissions were substantially different, projected emissions were instead taken from a recent year of emissions and held constant through the analytic years. The affected sources are shown in Table 4-13.

Table 4-13. Point oil and gas sources held constant at 2018 or 2019 levels

Inventory year	County FIPS	State	County	Facility ID	Facility Name
2018	17041	Illinois	Douglas Co	2749511	Trunkline Gas Co
2018	18003	Indiana	Allen Co	4544011	PANHANDLE EASTERN PIPE LINE CO EDGERT
2018	21197	Kentucky	Powell Co	5787411	TN Gas Pipeline Co LLC - Station 106
2018	39039	Ohio	Defiance Co	7938111	ANR Pipeline Company (0320010169)
2019	01129	Alabama	Washington Co	1028711	American Midstream Chatom, LLC
2019	04005	Arizona	Coconino Co	1115011	EPNG - WILLIAMS COMPRESSOR STATION
2019	05083	Arkansas	Logan Co	973211	DUNN COMPRESSOR STATION
2019	05091	Arkansas	Miller Co	7737711	NATURAL GAS PIPELINE CO OF AMERICA-305

Inventory year	County FIPS	State	County	Facility ID	Facility Name
2019	12007	Florida	Bradford Co	2574711	FLORIDA GAS TRANSMISSION COMPANY
2019	12095	Florida	Orange Co	845511	FLORIDA GAS TRANSMISSION COMPANY
2019	13195	Georgia	Madison Co	2803411	Transcontinental Gas Pipe Line Company, LLC - Compressor Station 130
2019	17183	Illinois	Vermilion Co	5401911	Midwestern Gas Transmission
2019	18037	Indiana	Dubois Co	4887211	ANR PIPELINE CO CELESTINE COMPRESSOR ST
2019	18075	Indiana	Jay Co	7957111	ANR PIPELINE COMPANY PORTLAND COMPRES
2019	19181	Iowa	Warren Co	2962011	NATURAL GAS PIPELINE CO OF AMERICA - STATION 108
2019	20057	Kansas	Ford Co	3839911	Natural Gas Pipeline of America - Minneola Station 103
2019	20067	Kansas	Grant Co	3508811	Scout Energy - Ulysses West Main Station
2019	20097	Kansas	Kiowa Co	5027511	Northern Natural Gas - Mullinville Station
2019	21089	Kentucky	Greenup Co	6096911	TN Gas Pipeline Co LLC - Station 200
2019	21107	Kentucky	Hopkins Co	5830611	ANR Pipeline Co (Madisonville Compressor Sta)
2019	22001	Louisiana	Acadia Par	6082411	ANR Pipeline Co - Eunice Compressor Station
2019	22001	Louisiana	Acadia Par	7364911	Florida Gas Transmission Co C/S 7
2019	22009	Louisiana	Avoyelles Par	5987211	Gulf South Pipeline Co LLC - Marksville Compressor Station
2019	22011	Louisiana	Beauregard Par	5998611	Transcontinental Gas Pipe Line Co LLC (TRANSCO) - Transco Compressor Station 45
2019	22013	Louisiana	Bienville Par	6000211	Southern Natural Gas Co - Bear Creek Storage Facility
2019	22021	Louisiana	Caldwell Par	6426511	Texas Gas Transmission LLC - Columbia Compressor Station
2019	22023	Louisiana	Cameron Par	13610511	Sabine Pass LNG LP - Sabine Pass Liquefaction LLC
2019	22053	Louisiana	Jefferson Davis Par	5283311	Tennessee Gas Pipeline Company LLC - Kinder Compressor Station 823
2019	22073	Louisiana	Ouachita Par	5735011	Enable Mississippi River Transmission LLC - Perryville Compressor Station
2019	22075	Louisiana	Plaquemines Par	7449511	East Bay Central Facility
2019	22079	Louisiana	Rapides Par	5740711	Columbia Gulf Transmission Co - Alexandria Compressor Station
2019	22079	Louisiana	Rapides Par	5740911	Texas Gas Transmission LLC - Pineville Compressor Station
2019	22083	Louisiana	Richland Par	5607811	ANR Pipeline Co - Delhi Compressor Station
2019	22087	Louisiana	St Bernard Par	5608211	Southern Natural Gas Co - Toca Compressor Station
2019	22113	Louisiana	Vermilion Par	5064311	Sea Robin Pipeline Co LLC - Erath Compressor Station
2019	22119	Louisiana	Webster Par	5357411	ETC Texas Pipeline Ltd - Minden Gas Plant
2019	22119	Louisiana	Webster Par	8019911	XTO Energy Inc - Cotton Valley Gas Plant

Inventory year	County FIPS	State	County	Facility ID	Facility Name
2019	26021	Michigan	Berrien Co	8195311	ANR Pipeline Company - Bridgman Compressor Station
2019	26035	Michigan	Clare Co	4007011	Great Lakes Gas - Farwell Compressor Station 12
2019	28063	Mississippi	Jefferson Co	7035611	TEXAS EASTERN TRANSMISSION LP, UNION CHU
2019	31131	Nebraska	Otoe Co	7767611	Northern Natural Gas Company
2019	37157	North Carolina	Rockingham Co	8492911	Transcontinental Gas Pipe Line Company, LLC - Station 160
2019	39045	Ohio	Fairfield Co	8259811	CRAWFORD COMPRESSOR STATION (0123000137)
2019	39059	Ohio	Guernsey Co	8008011	Kinder MorganTennessee Gas Pipeline Station 209 (0630000001)
2019	39157	Ohio	Tuscarawas Co	7996211	Dominion Energy Transmission, Inc. - Gilmore Station (0679000075)
2019	40007	Oklahoma	Beaver Co	8131911	BEAVER COMPRESSOR STATION
2019	40139	Oklahoma	Texas Co	8402511	TYRONE CMPSR STA
2019	47069	Tennessee	Hardeman Co	3787511	TENNESSEE GAS PIPELINE COMPANY L.L.C., STATION 71
2019	47079	Tennessee	Henry Co	2896511	ANR PIPELINE COMPANY, COTTAGE GROVE
2019	47181	Tennessee	Wayne Co	4188011	Tennessee Gas Pipeline Company, LLC - Compressor Station 555
2019	48003	Texas	Andrews Co	4171311	ANDREWS BOOSTER
2019	48003	Texas	Andrews Co	4898411	FULLERTON GAS PLANT
2019	48019	Texas	Bandera Co	4898811	BANDERA COMPRESSOR STATION
2019	48103	Texas	Crane Co	4163111	BLOCK 31 GAS PLANT
2019	48103	Texas	Crane Co	6492411	SAND HILLS PLANT
2019	48103	Texas	Crane Co	6507911	CRANE BOOSTER STATION
2019	48135	Texas	Ector Co	3968211	ANDECTOR BOOSTER STATION
2019	48135	Texas	Ector Co	6507511	GOLDSMITH GAS PLANT
2019	48195	Texas	Hansford Co	2904911	SHERHAN GAS PLANT
2019	48195	Texas	Hansford Co	6534211	EG HILL COMPRESSOR
2019	48227	Texas	Howard Co	5652011	EAST VEALMOOR GAS PLANT
2019	48241	Texas	Jasper Co	4862311	COMPRESSOR STATION 32
2019	48263	Texas	Kent Co	6379311	SALT CREEK FIELD GAS PLANT
2019	48329	Texas	Midland Co	4832311	PEGASUS GAS PLANT
2019	48371	Texas	Pecos Co	5765911	COYANOSA GAS PLANT
2019	48371	Texas	Pecos Co	6498211	YATES GAS PLANT
2019	48501	Texas	Yoakum Co	6648711	PLAINS COMPRESSOR STATION
2019	54021	West Virginia	Gilmer Co	6256711	Columbia Gas - GLENVILLE 4C1170
2019	54099	West Virginia	Wayne Co	6341411	Columbia Gas - CEREDO 4C3360

4.2.3.6 Non-EGU point sources (ptnonipm)

Packets:

Projection_2023_2026_finished_fuels_volpe_16jul2021_v0
Projection_2023_2026_industrial_byNAICS_SCC_version3_platform_07sep2022_v0
Projection_2023_2026_industrial_bySCC_version3_platform_09nov2022_v1
Projection_2023_2026_ptnonipm_version2_platform_MARAMA_23jul2021_nf_v1
projection_2023_2026interp_corn_ethanol_E0B0_Volpe_23jul2021_v0
Projection_2023_2026interp_ptnonipm_version2_platform_NC_23jul2021_v0
Projection_2023_2026interp_ptnonipm_version2_platform_NJ_23jul2021_v0
Projection_2023_2026interp_ptnonipm_version2_platform_VA_23jul2021_v0

To account for many changes to point sources between 2016 and 2023, following the removal of sources known to have closed between 2019 and 2023 emissions for the 2023 ptnonipm sector were set equal to emissions from the 2019 NEI point source emissions file dated March 25, 2022. The 2019 point source inventory was the most recent complete point source inventory available at the time the projections were performed. The 2019 emissions automatically included fuel changes and emissions controls applied during the intervening years. Due to this change in methodology, the factors provided by Wisconsin for use in the 2016v1 and 2016v2 platforms were no longer used.

The 2026 ptnonipm projections were projected from the 2023 point source emissions and involved several growth and projection methods described here. The projection of oil and gas sources is explained in the oil and gas section.

2023 and 2026 Point Inventory - inside MARAMA region

2023-to-2026 projection packets for point sources were based on the projection factors provided by MARAMA for the following states: CT, DE, DC, ME, MD, MA, NH, NJ, NY, NC, PA, RI, VT, VA, and WV. The factors were developed using the MARAMA projection tool and by selecting 2023 for the base year and 2026 for the projection year.

The MARAMA projection packets were used throughout the MARAMA region, except in North Carolina, New Jersey, and Virginia. Those three states provided their own projection packets for the ptnonipm sector in 2016v1, and those projection packets were used instead of the MARAMA packets in those states in 2016v2 and v3 as well. The Virginia growth factors for one facility were edited to incorporate emissions limits provided by MARAMA for that facility. A separate adjustment was made to emissions of a Pennsylvania source (process ID 13629614) based on updated information provided by MARAMA.

2026 Point Inventories - outside MARAMA region

Projection factors were developed by industrial sector from AEO 2022 in order to project emissions from 2023 to 2026. The SCCs were mapped to AEO categories and projection factors were created using a ratio between the base year and projection year estimates from each specific AEO category. Table 4-14 below details the AEO2022tables used to map SCCs to AEO categories for the projections of industrial sources. Depending on the category, a projection factor may be national or regional. The maximum projection factor for projecting from 2023 to 2026 was capped at 1.3. MARAMA states were not projected using this method. Also in 2016v2 and 2016v3, more SCCs were mapped to the AEO categories for SCCs that had not been projected in 2016v1. For example, SCCs for the cement kilns that did not specify a fuel are now mapped to the "Value of Shipments" as a generic indicator for projected growth.

An SCC-NAICS projection was also developed using AEO2022. SCC/NAICS combinations with emissions >100tons/year for any CAP[39] were mapped to AEO sector and fuel. Projection factors for this method were capped at 1.3 for projecting emissions from 2023 to 2026.

New units were added for 2016v2 and carried into 2016v3 based on 2018NEI analysis, although these are also added in 2016 as described in Section 2.1.3. Emissions for taconite-related facilities in Minnesota were replaced with preliminary 2021 emissions obtained from the state. These emissions should reflect controls that are installed at those facilities between 2016 and 2021. In addition, reductions for the Fernley Plant in Nevada are implemented in the 2026 inventory due to the timing of the planned controls in response to the consent decree reached for EPA case number 09-2011-0506[40] expected to come online between 2023 and 2026.

Any control efficiencies that were set to 100 in the 2016 base year inventory were identified and adjusted prior to projecting the inventories. Note that a control efficiency equal to 100 means that there would be no emissions, so control efficiencies equal to 100 are assumed to be in error.

Table 4-14. Annual Energy Outlook (AEO) 2022 tables used to project industrial sources

AEO 2022 Table #	AEO Table name
2	Energy Consumption by Sector and Source
24	Refining Industry Energy Consumption
25	Food Industry Energy Consumption
26	Paper Industry Energy Consumption
27	Bulk Chemical Industry Energy Consumption
28	Glass Industry Energy Consumption
29	Cement Industry Energy Consumption
30	Iron and Steel Industries Energy Consumption
31	Aluminum Industry Energy Consumption
32	Metal Based Durables Energy Consumption
33	Other Manufacturing Sector Energy Consumption
34	Nonmanufacturing Sector Energy Consumption

4.2.3.7 Airport sources (airports)

Packets:

airport_projections_itn_taf2021_2016_2023_25apr2022_v0
airport_projections_itn_taf2021_2016_2026_25apr2022_v0

Airport emissions for 2016v3 were projected from the 2016 airport emissions to 2023 and 2026 using the same projection approach as for 2016v1 and 2016v2, but the factors were based on TAF 2021 based on the corrected 2017 NEI airport emissions (released in June 2022), and starting from the base year 2016

[39] The "100 tpy" criterion for this purpose was based on emissions in the emissions values in the 2016 beta platform.
[40] https://echo.epa.gov/enforcement-case-report?activity_id=2600059825

instead of 2017. The Terminal Area Forecast (TAF) data available from the Federal Aviation Administration (see https://www.faa.gov/data_research/aviation/taf/).

Projection factors were computed using the ratio of the itinerant (ITN) data from the Airport Operations table between the base and projection year. Where possible, airport-specific projection factors were used. For airports that could not be matched to a unit in the TAF data, state default growth factors by itinerant class (i.e., commercial, air taxi, and general) were created from the set of unmatched airports. Emission growth for facilities from 2016 to 2023 and 2026 was capped at 500% and the state default growth was capped at 200%. Military state default projection values were kept flat (i.e., equal to 1.0) to reflect uncertainly in the data regarding these sources.

4.2.3.8 Nonpoint Sources (nonpt)

Packets:

Projection_2016_2023_all_nonpoint_version1_platform_NC_04oct2019_v2
Projection_2016_2023_finished_fuels_volpe_04oct2019_v2
Projection_2016_2023_industrial_bySCC_version3_platform_09nov2022_v1
Projection_2016_2023_nonpt_other_version3_platform_MARAMA_22aug2022_v0
Projection_2016_2023_nonpt_PFC_version1_platform_MARAMA_20sep2019_v1
Projection_2016_2023_nonpt_population_beta_platform_ext_20sep2019_v1
Projection_2016_2023_nonpt_version1_platform_NJ_04oct2019_v1
Projection_2016_2026_all_nonpoint_version2_platform_NC_30aug2022_nf_v2
Projection_2016_2026_finished_fuels_volpe_16jul2021_v0
Projection_2016_2026_industrial_bySCC_version3_platform_09nov2022_v1
Projection_2016_2026_nonpt_other_version3_platform_MARAMA_22aug2022_v0
Projection_2016_2026_nonpt_PFC_version2_platform_MARAMA_noNC_16jul2021_v1
Projection_2016_2026_nonpt_population_version2_platform_noMARAMA_16jul2021_v0
Projection_2016_2026_nonpt_version2_platform_NJ_16jul2021_v0

In 2016v3, emissions sources in the nonpt sectors are based on 2017 NEI, which was determined to better represent 2017 emissions than the 2014 NEI emissions projected to 2016 using factors based on surrogates such as changes in population and employment. Therefore, controls fully implemented by 2017, such as sulfur rules in some northeast states and boiler rules, do not need to be reflected in these projection factors. The projected 2023 and 2026 emissions were developed by applying the factors in the projection packets to the base year emissions.

Inside MARAMA region

2016-to-2023 and 2016-to-2026 projection packets for all nonpoint sources were provided by MARAMA for the following states and updated with data from AEO2022: CT, DE, DC, ME, MD, MA, NH, NJ, NY, NC, PA, RI, VT, VA, and WV. MARAMA provided one projection packet per year for portable fuel containers (PFCs), and a second projection packet per year for all other nonpt sources.

The MARAMA projection packets were used throughout the MARAMA region, except in North Carolina and New Jersey. Both NC and NJ provided separate projection packets for the nonpt sector for 2016v1 and those projection packets were used instead of the MARAMA packets in those two states. New Jersey did not provide projection factors for PFCs, and so NJ PFCs were projected using the MARAMA PFC growth packet.

Industrial Sources outside MARAMA region

Because each AEO only includes data for one or two years prior to its publication year, projection factors were developed from 2016 to 2023 and 2016 to 2026 by industrial sector using a series of AEOs to cover the period from 2016 through 2023: AEO2018 was used to go from 2016 to 2017; AEO2019 to go from 2017 to 2020; AEO2021 to go from 2020 to 2021; and AEO2022 to go from 2021 to 2023 and 2026. SCCs were mapped to AEO categories and projection factors were created using a ratio between the base year and projection year estimates from each specific AEO category. For the nonpt sector, only AEO Table 2 was used to map SCCs to AEO categories for the projections of industrial sources. Depending on the category, a projection factor may be national or regional. The maximum projection factor was capped at a factor of 1.75 for 2016 to 2023, and a factor of 2.25 for 2016 to 2026. Sources within the MARAMA region were not projected with these factors, but with the MARAMA-provided growth factors.

In response to comments, a change in the 2016v3 platform was to hold distillate emissions for SCCs 2103004000, 2103004001, and 2103004002 flat with a 1.0 projection factor instead of showing increasing emissions in 2023 and 2026.

Evaporative Emissions from Transport of Finished Fuels outside MARAMA region

Estimates on growth of evaporative emissions from transporting finished fuels are partially covered in the nonpoint and point oil and gas projection packets. However, there are some processes with evaporative emissions from storing and transporting finished fuels which are not included in the nonpoint and point oil and gas projection packets, e.g., withdrawing fuel from tanks at bulk plants, filling tanks at service stations, etc., and those processes are included in nonpoint other. AEO2018 was used as a starting point for projecting volumes of finished fuel that would be transported in analytic years. Then these volumes were used to calculate inventories associated with evaporative emissions in 2016, 2023, and 2028 using upstream modules in the Emissions Modeling Framework. Those emission inventories were mapped to the appropriate SCCs and projection packets were generated from 2016 to 2023 and 2016 to 2028 using the upstream modules. Inventories for 2026 were developed by interpolating between the inventories for 2023 and 2028. Sources within the MARAMA region were not projected with these factors, but with the MARAMA-provided growth factors.

Human Population Growth outside MARAMA region

For SCCs that were projected based on human population growth, population projection data were available from the Benefits Mapping and Analysis Program (BenMAP) model by county for several years, including 2017, 2023, and 2026. These human population data were used to create modified county-specific projection factors. The impacted SCCs are shown in Table 4-15. Note that 2017 is being used as the base year since 2016 human population is not available in this dataset. A newer human population dataset was assessed but it did not have realistic near-term (e.g., 2023/2026) projections, and was not used; for example, rural areas of NC were projected to have more growth than urban areas, which is the opposite of what one would expect. Growth factors were limited to 5% cumulative annual growth (e.g. 35% annual growth over 7 years), but none of the factors fell outside that range. Sources within the MARAMA region were not projected with these factors, but with the MARAMA-provided growth factors.

Table 4-15. SCCs in nonpt that use Human Population Growth for Projections

SCC	Description
2302002100	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Charbroiling;Conveyorized Charbroiling
2302002200	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Charbroiling;Under-fired Charbroiling
2302003000	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Frying;Deep Fat Frying
2302003100	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Frying;Flat Griddle Frying
2302003200	Industrial Processes;Food and Kindred Products: SIC 20;Commercial Cooking - Frying;Clamshell Griddle Frying
2501011011	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Permeation
2501011012	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Evaporation (includes Diurnal losses)
2501011013	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Spillage During Transport
2501011014	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Refilling at the Pump - Vapor Displacement
2501011015	Storage and Transport;Petroleum and Petroleum Product Storage;Residential Portable Gas Cans;Refilling at the Pump – Spillage
2501012011	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Permeation
2501012012	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Evaporation (includes Diurnal losses)
2501012013	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Spillage During Transport
2501012014	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Refilling at the Pump - Vapor Displacement
2501012015	Storage and Transport;Petroleum and Petroleum Product Storage;Commercial Portable Gas Cans;Refilling at the Pump – Spillage
2630020000	Waste Disposal, Treatment, and Recovery;Wastewater Treatment;Public Owned;Total Processed
2640000000	Waste Disposal, Treatment, and Recovery;TSDFs;All TSDF Types;Total: All Processes
2810025000	Miscellaneous Area Sources;Other Combustion;Residential Grilling (see 23-02-002-xxx for Commercial);Total
2810060100	Miscellaneous Area Sources;Other Combustion;Cremation;Humans

4.2.3.9 Solvents (np_solvents)

Packets:

Projection_2016_2023_solvents_v2platform_MARAMA_noNCNJ_09nov2022_v2
Projection_2016_2023_solvents_v2platform_NC_09nov2022_v2
Projection_2016_2023_solvents_v2platform_NJ_09nov2022_v1
Projection_2016_2023_solvents_v2platform_population_noMARAMA_09nov2022_v1
Projection_2016_202X_solvents_v3platform_Idaho_asphalt_09aug2022_v0
Projection_2016_2026_solvents_v2platform_MARAMA_noNCNJ_09nov2022_v1
Projection_2016_2026_solvents_v2platform_NC_09nov2022_v1

Projection_2016_2026_solvents_v2platform_NJ_09nov2022_v1
Projection_2016_2026_solvents_v2platform_population_noMARAMA_09nov2022_v1

The projection methodology for np_solvents is similar to the method used in the 2016v2 platform. The MARAMA, NC, and NJ nonpt projection packets all affect solvents. Elsewhere, solvents are projected using human population trends for most solvent categories. All of these packets were checked to confirm they cover all SCCs in the solvents sector, and packets were supplemented with additional SCCs as needed, copied from factors for existing SCCs. The SCCs in np_solvents that are projected using human population growth are shown in Table 4-16.

The following updates were made in 2016v3 to supplement the SCCs included in the projection packets:

- all 2460- SCCs and 2402000000 use human population (copied from an existing 2460- SCC);
- most surface coating and graphic arts SCCs use either human population (MARAMA and non-MARAMA regions) or employment data (some SCCs in MARAMA region only);
- added new SCC 2460030999 (lighter fluid) to project based on human population in all regions.

The 2026 projection packets were interpolated from 2023 and 2028 for NC and NJ. Two SCCs which were projected based on VMT in North Carolina used 2016v3 VMT as the basis for those projections.

For 2016v3, Idaho asphalt emissions (SCCs = 2461021000, 2461022000) were reduced by 14.2% based on a comment from the state.

Table 4-16. SCCs in np_solvents that use Human Population Growth for Projections

SCC	SCC Descriptions
2401001000	Solvent Utilization;Surface Coating;Architectural Coatings;Total: All Solvent Types
2401005000	Solvent Utilization;Surface Coating;Auto Refinishing: SIC 7532;Total: All Solvent Types
2401005700	Solvent Utilization;Surface Coating;Auto Refinishing: SIC 7532;Top Coats
2401008000	Solvent Utilization;Surface Coating;Traffic Markings;Total: All Solvent Types
2401010000	Solvent Utilization;Surface Coating;Textile Products: SIC 22;Total: All Solvent Types
2401015000	Solvent Utilization;Surface Coating;Factory Finished Wood: SIC 2426 thru 242;Total: All Solvent Types
2401020000	Solvent Utilization;Surface Coating;Wood Furniture: SIC 25;Total: All Solvent Types
2401025000	Solvent Utilization;Surface Coating;Metal Furniture: SIC 25;Total: All Solvent Types
2401030000	Solvent Utilization;Surface Coating;Paper: SIC 26;Total: All Solvent Types
2401035000	Solvent Utilization;Surface Coating;Plastic Products: SIC 308;Total: All Solvent Types
2401040000	Solvent Utilization;Surface Coating;Metal Cans: SIC 341;Total: All Solvent Types
2401045000	Solvent Utilization;Surface Coating;Metal Coils: SIC 3498;Total: All Solvent Types
2401050000	Solvent Utilization;Surface Coating;Miscellaneous Finished Metals: SIC 34 - (341 + 3498);Total: All Solvent Types
2401055000	Solvent Utilization;Surface Coating;Machinery and Equipment: SIC 35;Total: All Solvent Types
2401060000	Solvent Utilization;Surface Coating;Large Appliances: SIC 363;Total: All Solvent Types
2401065000	Solvent Utilization;Surface Coating;Electronic and Other Electrical: SIC 36 - 363;Total: All Solvent Types
2401070000	Solvent Utilization;Surface Coating;Motor Vehicles: SIC 371;Total: All Solvent Types
2401075000	Solvent Utilization;Surface Coating;Aircraft: SIC 372;Total: All Solvent Types
2401080000	Solvent Utilization;Surface Coating;Marine: SIC 373;Total: All Solvent Types
2401085000	Solvent Utilization;Surface Coating;Railroad: SIC 374;Total: All Solvent Types

SCC	SCC Descriptions
2401090000	Solvent Utilization;Surface Coating;Miscellaneous Manufacturing;Total: All Solvent Types
2401100000	Solvent Utilization;Surface Coating;Industrial Maintenance Coatings;Total: All Solvent Types
2401200000	Solvent Utilization;Surface Coating;Other Special Purpose Coatings;Total: All Solvent Types
2425000000	Solvent Utilization;Graphic Arts;All Processes;Total: All Solvent Types
2425020000	Solvent Utilization;Graphic Arts;Letterpress;Total: All Solvent Types
2425030000	Solvent Utilization;Graphic Arts;Rotogravure;Total: All Solvent Types
2440000000	Solvent Utilization;Miscellaneous Industrial;All Processes;Total: All Solvent Types
2440020000	Solvent Utilization;Miscellaneous Industrial;Adhesive (Industrial) Application;Total: All Solvent Types
2460030999	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;Lighter Fluid, Fire Starter, Other Fuels;Total: All Volatile Chemical Product Types
2460100000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Personal Care Products;Total: All Solvent Types
2460200000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Household Products;Total: All Solvent Types
2460400000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Automotive Aftermarket Products;Total: All Solvent Types
2460500000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Coatings and Related Products;Total: All Solvent Types
2460600000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All Adhesives and Sealants;Total: All Solvent Types
2460800000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;All FIFRA Related Products;Total: All Solvent Types
2460900000	Solvent Utilization;Miscellaneous Non-industrial: Consumer and Commercial;Miscellaneous Products (Not Otherwise Covered);Total: All Solvent Types
2461800001	Solvent Utilization;Miscellaneous Non-industrial: Commercial;Pesticide Application: All Processes;Surface Application

4.2.3.10 Residential Wood Combustion (rwc)

Packets:

Projection_2016_2023_all_nonpoint_version1_platform_NC_24jun2021_nf_v5
Projection_2016_2023_rwc_version2_platform_fromMARAMA_22jun2021_v0
Projection_2016_2026_all_nonpoint_version2_platform_NC_19jul2021_nf_v1
Projection_2016_2026_rwc_version2_platform_fromMARAMA_19jul2021_v0

For residential wood combustion, the growth and control factors are computed together into merged factors in the same packets. For states other than California, Oregon, and Washington, RWC emissions from 2016 were projected to 2023 and 2026 using projection factors derived using the MARAMA tool that is based on the projection methodology from EPA's 2011v6.3 platform. The development of projected growth in RWC emissions to year 2023 starts with the projected growth in RWC appliances derived from year 2012 appliance shipments reported in the Regulatory Impact Analysis (RIA) for Proposed Residential Wood Heaters NSPS Revision Final Report available at: http://www2.epa.gov/sites/production/files/2013-12/documents/ria-20140103.pdf. The 2012 shipments are based on 2008 shipment data and revenue forecasts from a Frost & Sullivan Market Report (Frost &

Sullivan, 2010). Next, to be consistent with the RIA, growth rates for new appliances for certified wood stoves, pellet stoves, indoor furnaces and OHH were based on forecasted revenue (real GDP) growth rate of 2.0% per year from 2013 through 2023 and 2026 as predicted by the U.S. Bureau of Economic Analysis (BEA, 2012). While this approach is not perfectly correlated, in the absence of specific shipment projections, the RIA assumes the overall trend in the projection is reasonable. The growth rates for appliances not listed in the RIA (fireplaces, outdoor wood burning devices (not elsewhere classified) and residential fire logs) are estimated based on the average growth in the number of houses between 2002 and 2012, about 1% (U.S. Census, 2012).

In addition to new appliance sales and forecasts extrapolating beyond 2012, assumptions on the replacement of older, existing appliances are needed. Based on long lifetimes, no replacement of fireplaces, outdoor wood burning devices (not elsewhere classified) or residential fire logs is assumed. It is assumed that 95% of new woodstoves will replace older non-EPA certified freestanding stoves (pre-1988 NSPS) and 5% will replace existing EPA-certified catalytic and non-catalytic stoves that currently meet the 1988 NSPS (Houck, 2011).

Equation 4-1 was applied with RWC-specific factors from the rule. The EPA RWC NSPS experts assume that 10% of new pellet stoves and OHH replace older units and that because of their short lifespan, that 10% of indoor furnaces are replaced each year; these are the same assumptions used since the 2007 emissions modeling platform (EPA, 2012d). The resulting growth factors for these appliance types varies by appliance type and also by pollutant because the emission rates, from EPA RWC tool (EPA, 2013rwc), vary by appliance type and pollutant. For EPA certified units, the projection factors for PM are lower than those for all other pollutants. The projection factors also vary because the total number of existing units in 2016 varies greatly between appliance types. For 2016v3, the projection factors are the same as those used in 2016v2, although the rwc emissions for Idaho differ due to the 2016 emissions being updated to use data from 2017 NEI.

Table 4-17 contains the factors to adjust the emissions from 2016 to 2023 and 2026. California, Oregon, and Washington RWC were held constant at 2017 NEI levels for all of the years 2016, 2023, and 2026 due to the unique control programs that those states have in place.

Table 4-17. Projection factors for RWC

SCC	SCC description	Pollutant*	2016-to-2023	2016-to-2026
2104008100	Fireplace: general		7.19%	10.29%
2104008210	Woodstove: fireplace inserts; non-EPA certified		-13.92%	-17.97%
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic	PM10-PRI	4.09%	5.08%
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic	PM25-PRI	4.09%	5.08%
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic		8.34%	10.28%
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic	PM10-PRI	6.06%	7.68%
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic	PM25-PRI	6.06%	7.68%
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic		12.08%	15.27%

SCC	SCC description	Pollutant*	2016-to-2023	2016-to-2026
2104008310	Woodstove: freestanding, non-EPA certified	CO	-12.09%	-15.72%
2104008310	Woodstove: freestanding, non-EPA certified	PM10-PRI	-12.67%	-16.52%
2104008310	Woodstove: freestanding, non-EPA certified	PM25-PRI	-12.67%	-16.52%
2104008310	Woodstove: freestanding, non-EPA certified	VOC	-11.40%	-14.84%
2104008310	Woodstove: freestanding, non-EPA certified		-12.09%	-15.72%
2104008320	Woodstove: freestanding, EPA certified, non-catalytic	PM10-PRI	4.09%	5.08%
2104008320	Woodstove: freestanding, EPA certified, non-catalytic	PM25-PRI	4.09%	5.08%
2104008320	Woodstove: freestanding, EPA certified, non-catalytic		8.34%	10.28%
2104008330	Woodstove: freestanding, EPA certified, catalytic	PM10-PRI	6.07%	7.69%
2104008330	Woodstove: freestanding, EPA certified, catalytic	PM25-PRI	6.07%	7.69%
2104008330	Woodstove: freestanding, EPA certified, catalytic		12.08%	15.27%
2104008400	Woodstove: pellet-fired, general (freestanding or FP insert)	PM10-PRI	30.09%	38.02%
2104008400	Woodstove: pellet-fired, general (freestanding or FP insert)	PM25-PRI	30.09%	38.02%
2104008400	Woodstove: pellet-fired, general (freestanding or FP insert)		26.96%	33.85%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	CO	-64.93%	-84.78%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	PM10-PRI	-62.99%	-82.89%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	PM25-PRI	-62.99%	-82.89%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	VOC	-65.02%	-84.89%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified		-64.93%	-84.78%
2104008530	Furnace: Indoor, pellet-fired, general	PM10-PRI	30.09%	38.02%
2104008530	Furnace: Indoor, pellet-fired, general	PM25-PRI	30.09%	38.02%
2104008530	Furnace: Indoor, pellet-fired, general		26.96%	33.85%
2104008610	Hydronic heater: outdoor	PM10-PRI	0.06%	-0.40%
2104008610	Hydronic heater: outdoor	PM25-PRI	0.06%	-0.40%
2104008610	Hydronic heater: outdoor		-0.73%	-1.30%
2104008620	Hydronic heater: indoor	PM10-PRI	0.06%	-0.40%
2104008620	Hydronic heater: indoor	PM25-PRI	0.06%	-0.40%
2104008620	Hydronic heater: indoor		-0.73%	-1.30%
2104008630	Hydronic heater: pellet-fired	PM10-PRI	0.06%	-0.40%
2104008630	Hydronic heater: pellet-fired	PM25-PRI	0.06%	-0.40%

SCC	SCC description	Pollutant*	2016-to-2023	2016-to-2026
2104008630	Hydronic heater: pellet-fired		-0.73%	-1.30%
2104008700	Outdoor wood burning device, NEC (fire-pits, chimineas, etc)		7.19%	9.25%
2104009000	Fire log total		7.19%	9.25%

* If no pollutant is specified, facture is used for any pollutants that do not have a pollutant-specific factor

4.2.4 CoST CONTROL Packets (nonpt, np_oilgas, ptnonipm, pt_oilgas, np_solvents)

The final step in the projection of emissions to each analytic year is the application of any control technologies or programs. For analytic-year New Source Performance Standards (NSPS) controls (e.g., oil and gas, Reciprocating Internal Combustion Engines (RICE), Natural Gas Turbines, and Process Heaters), we attempted to control only new sources/equipment using the following equation to account for growth and retirement of existing sources and the differences between the new and existing source emission rates.

$$Qn = Qo \{ [(1 + Pf) t - 1] Fn + (1 - Ri) t \; Fe + [1 - (1 - Ri) t] Fn] \}$$ **Equation 4-1**

where:

Qn = emissions in projection year
Qo = emissions in base year
Pf = growth rate expressed as ratio (e.g., 1.5=50 percent cumulative growth)
t = number of years between base and analytic years
Fn = emission factor ratio for new sources
Ri = retirement rate, expressed as whole number (e.g., 3.3 percent=0.033)
Fe = emission factor ratio for existing sources

The first term in Equation 4-1 represents new source growth and controls, the second term accounts for retirement and controls for existing sources, and the third term accounts for replacement source controls. For computing the CoST % reductions (Control Efficiency), the simplified Equation 4-2 was used for 2023 and 2026 projections:

$$\text{Control Efficiency}_{202x}(\%) = 100 \times \left(1 - \frac{[(Pf_{202x}-1)\times Fn + (1-Ri)^{12} + (1-(1-Ri)^{12})\times Fn]}{Pf_{202x}}\right)$$ **Equation 4-2**

For example, to compute the control efficiency for 2028 from a base year of 2015 the existing source emissions factor (Fe) is set to 1.0, 2028 (analytic year) minus 2016 (base year) is 12, and new source emission factor (Fn) is the ratio of the NSPS emission factor to the existing emission factor. Table 4-18 shows the values for Retirement rate and new source emission factors (Fn) for new sources with respect to each NSPS regulation and other conditions within. For the nonpt sector, the RICE NSPS control program was applied when estimating year 2023 and 2026 emissions for the 2016v3 modeling platform. Further information about the application of NSPS controls can be found in Section 4 of the *Additional Updates* *to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2023* technical support document (EPA, 2017).

Table 4-18. Assumed retirement rates and new source emission factor ratios for NSPS rules

NSPS Rule	Sector(s)	Retirement Rate years (%/year)	Pollutant Impacted	Applied where?	New Source Emission Factor (Fn)
Oil and Gas	np_oilgas, pt_oilgas	No assumption	VOC	Storage Tanks: 70.3% reduction in growth-only (>1.0)	0.297
				Gas Well Completions: 95% control (regardless)	0.05
				Pneumatic controllers, not high-bleed >6scfm or low-bleed: 77% reduction in growth-only (>1.0)	0.23
				Pneumatic controllers, high-bleed >6scfm or low-bleed: 100% reduction in growth-only (>1.0)	0.00
				Compressor Seals: 79.9% reduction in growth-only (>1.0)	0.201
				Fugitive Emissions: 60% Valves, flanges, connections, pumps, open-ended lines, and other	0.40
				Pneumatic Pumps: 71.3%; Oil and Gas	0.287
RICE	np_oilgas, pt_oilgas, nonpt, ptnonipm	40, (2.5%)	NO_X	Lean burn: PA, all other states	0.25, 0.606
				Rich Burn: PA, all other states	0.1, 0.069
				Combined (average) LB/RB: PA, other states	0.175, 0.338
			CO	Lean burn: PA, all other states	1.0 (n/a), 0.889
				Rich Burn: PA, all other states	0.15, 0.25
				Combined (average) LB/RB: PA, other states	0.575, 0.569
			VOC	Lean burn: PA, all other states	0.125, n/a
				Rich Burn: PA, all other states	0.1, n/a
				Combined (average) LB/RB: PA, other states	0.1125, n/a
Gas Turbines	pt_oilgas, ptnonipm	45 (2.2%)	NO_X	California and NO_X SIP Call states	0.595
				All other states	0.238
Process Heaters	pt_oilgas, ptnonipm	30 (3.3%)	NO_X	Nationally to Process Heater SCCs	0.41

4.2.4.1 Oil and Gas NSPS (np_oilgas, pt_oilgas)

Packets:

Control_2016_2023_Oilgas_NSPS_np_oilgas_v3_platform_07sep2022_v1
Control_2016_2023_Oilgas_NSPS_pt_oilgas_v3_platform_07sep2022_v1
Control_2016_2026_Oilgas_NSPS_np_oilgas_v3_platform_09nov2022_v1
Control_2016_2026_Oilgas_NSPS_pt_oilgas_v3_platform_09nov2022_v1

New packets to reflect the oil and gas NSPS were developed for the 2016v3 platform. For oil and gas NSPS controls, except for gas well completions (a 95 percent control), the assumption of no equipment retirements through year 2026 dictates that NSPS controls are applied to the growth component only of any PROJECTION factors. For example, if a growth factor is 1.5 for storage tanks (indicating a 50 percent increase activity), then, using Table 4-18, the 70.3 percent VOC NSPS control to this new growth will result in a 23.4 percent control: 100 *(70.3 * (1.5 -1) / 1.5); this yields an "effective" growth rate (combined PROJECTION and CONTROL) of 1.1485, or a 70.3 percent reduction from 1.5 to 1.0. The impacts of all non-drilling completion VOC NSPS controls are therefore greater where growth in oil and gas production is assumed highest. Conversely, for oil and gas basins with assumed negative growth in activity/production, VOC NSPS controls will be limited to well completions only. These reductions are year-specific because projection factors for these sources are year-specific. Table 4-19 (np_oilgas) and Table 4-21 (pt_oilgas) list the SCCs where Oil and Gas NSPS controls were applied; note controls are applied to production and exploration-related SCCs. Table 4-20 (np_oilgas) and Table 4-22 (pt_oilgas) shows the reduction in VOC emissions after the application of the Oil and Gas NSPS CONTROL packet for analytic years. The emissions totals in these tables include emissions in WRAP states, although WRAP states other than New Mexico use a separate analytic year inventory. Additional effort was implemented to reflect New Mexico's new Oil and Gas rule as a 60% reduction to VOC for three SCCs (2310010700, 2310021509, and 2310023509). These additional controls in New Mexico Administrative code 20.2.50[41] were reflected in the overall "Oil and Gas NSPS" control packet so that they could be included in time to develop the new inventories for use in the 2016v3 emissions modeling platform.

Table 4-19. Non-point (np_oilgas) SCCs in 2016v3 modeling platform where Oil and Gas NSPS controls applied

SCC	PRODUCT	OG_NSPS_SCC	TOOL OR STATE	SRC_CAT	SCC_Description
2310010300	OIL	3. Pnuematic controllers: not high or low bleed	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Crude Petroleum;Oil Well Pneumatic Devices;;
2310010700	OIL	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Crude Petroleum;Oil Well Fugitives;;
2310011020	OIL	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Storage Tanks: Crude Oil;;
2310011500	OIL	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: All Processes;;
2310011501	OIL	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Connectors;;
2310011502	OIL	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Flanges;;
2310011503	OIL	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Open Ended Lines;;
2310011505	OIL	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Valves;;
2310011506	OIL	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Other;;

[41] See https://www.srca.nm.gov/parts/title20/20.002.0050.html and https://www.env.nm.gov/air-quality/compliance-and-enforcement/

SCC	PRODUCT	OG_NSPS_SCC	TOOL OR STATE	SRC_CAT	SCC_Description
2310020700	NGAS	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas;Gas Well Fugitives;;
2310021010	NGAS	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Storage Tanks: Condensate;;
2310021011	NGAS	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Condensate Tank Flaring;;
2310021300	NGAS	3. Pnuematic controllers: not high or low bleed	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Pneumatic Devices;;
2310021310	NGAS	6. Pneumatic Pumps	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Pneumatic Pumps;;
2310021500	NGAS	2. Well Completions	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Completion - Flaring;;
2310021501	NGAS	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Connectors;;
2310021502	NGAS	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Flanges;;
2310021503	NGAS	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Open Ended Lines;;
2310021505	NGAS	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Valves;;
2310021506	NGAS	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Other;;
2310021509	NGAS	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: All Processes;;
2310021601	NGAS	2. Well Completions	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Venting - Initial Completions;;
2310023000	CBM	6. Pneumatic Pumps	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Dewatering Pump Engines;;
2310023010	CBM	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Storage Tanks: Condensate;;
2310023300	CBM	3. Pnuematic controllers: not high or low bleed	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Pneumatic Devices;;
2310023310	CBM	6. Pneumatic Pumps	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Pneumatic Pumps;;
2310023509	CBM	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives;;
2310023511	CBM	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Connectors;;
2310023512	CBM	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Flanges;;

SCC	PRODUCT	OG_NSPS_SCC	TOOL OR STATE	SRC_CAT	SCC_Description
2310023513	CBM	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Open Ended Lines;;
2310023515	CBM	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Valves;;
2310023516	CBM	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Other;;
2310023600	CBM	2. Well Completions	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Well Completion: All Processes;;
2310030220	NGAS	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas Liquids;Gas Well Tanks - Flashing & Standing/Working/Breathing, Controlled;;
2310030300	NGAS	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas Liquids;Gas Well Water Tank Losses;;
2310111401	OIL	6. Pneumatic Pumps	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Exploration;Oil Well Pneumatic Pumps;;
2310111700	OIL	2. Well Completions	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Exploration;Oil Well Completion: All Processes;;
2310121401	NGAS	6. Pneumatic Pumps	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Exploration;Gas Well Pneumatic Pumps;;
2310121700	NGAS	2. Well Completions	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Exploration;Gas Well Completion: All Processes;;
2310321010	NGAS	1. Storage Tanks	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Conventional;Storage Tanks: Condensate;;
2310421010	NGAS	1. Storage Tanks	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Unconventional;Storage Tanks: Condensate;;

Table 4-20. Emissions reductions for np_oilgas sector due to application of Oil and Gas NSPS

year	poll	2016v3	2016 pre-CoST emissions	emissions change from 2016	% change
2023	VOC	2543889	2591022	-666598	-25.7%
2026	VOC	2543889	2591022	-721370	-27.8%

Table 4-21. Point source SCCs in pt_oilgas sector where Oil and Gas NSPS controls were applied

SCC	GAS or OIL	OG_NSPS_ SCC	TOOL OR STATE	SRC_CAT	NP_PT_ NPPT	SCC_Description
30180010	NGAS	4. Compressor Seals	STATE	PRODUCTION	PT	Industrial Processes;Chemical Manufacturing;Equipment Leaks;Compressor Seals: Gas Stream;;
30600801	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Pipeline Valves and Flanges;;

SCC	GAS or OIL	OG_NSPS_ SCC	TOOL OR STATE	SRC_CAT	NP_PT_ NPPT	SCC_Description
30600802	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Vessel Relief Valves;;
30600803	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Pump Seals w/o Controls;;
30600804	OIL	4. Compressor Seals	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Compressor Seals;;
30600805	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Miscellaneous: Sampling/Non-Asphalt Blowing/Purging/etc.;;
30600806	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Pump Seals with Controls;;
30600811	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Pipeline Valves: Gas Streams;;
30600812	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Pipeline Valves: Light Liquid/Gas Streams;;
30600813	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Pipeline Valves: Heavy Liquid Streams;;
30600815	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Open-ended Valves: All Streams;;
30600816	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Flanges: All Streams;;
30600817	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Pump Seals: Light Liquid/Gas Streams;;
30600818	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Pump Seals: Heavy Liquid Streams;;
30600819	OIL	4. Compressor Seals	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Compressor Seals: Gas Streams;;
30600820	OIL	4. Compressor Seals	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Compressor Seals: Heavy Liquid Streams;;
30600822	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Vessel Relief Valves: All Streams;;
30688801	OIL	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Petroleum Industry;Fugitive Emissions;Specify in Comments Field;;
31000101	OIL	2. Well Completions	STATE	EXPLORATION	PT	Industrial Processes;Oil and Gas Production;Crude Oil Production;Well Completion;;
31000130	OIL	4. Compressor Seals	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Crude Oil Production;Fugitives: Compressor Seals;;
31000151	OIL	3. Pnuematic controllers: high or low bleed	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Crude Oil Production;Pneumatic Controllers, Low Bleed;;
31000152	OIL	3. Pnuematic controllers: high or low bleed	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Crude Oil Production;Pneumatic Controllers High Bleed >6 scfh;;
31000153	OIL	3. Pnuematic controllers: not high or low bleed	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Crude Oil Production;Pneumatic Controllers Intermittent Bleed;;
31000207	NGAS	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Natural Gas Production;Valves: Fugitive Emissions;;

SCC	GAS or OIL	OG_NSPS_SCC	TOOL OR STATE	SRC_CAT	NP_PT_NPPT	SCC_Description
31000220	NGAS	5. Fugitives	STATE	PRODUCTION	NP_AND_PT	Industrial Processes;Oil and Gas Production;Natural Gas Production;All Equipt Leak Fugitives (Valves, Flanges, Connections, Seals, Drains;;
31000225	NGAS	4. Compressor Seals	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Natural Gas Production;Compressor Seals;;
31000231	NGAS	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Natural Gas Production;Fugitives: Drains;;
31000233	NGAS	3. Pnuematic controllers: high or low bleed	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Natural Gas Production;Pneumatic Controllers, Low Bleed;;
31000235	NGAS	3. Pnuematic controllers: not high or low bleed	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Natural Gas Production;Pneumatic Controllers Intermittent Bleed;;
31000309	NGAS	4. Compressor Seals	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Natural Gas Processing;Compressor Seals;;
31000324	NGAS	3. Pnuematic controllers: high or low bleed	STATE	PRODUCTION	NP_AND_PT	Industrial Processes;Oil and Gas Production;Natural Gas Processing;Pneumatic Controllers Low Bleed;;
31000325	NGAS	3. Pnuematic controllers: high or low bleed	STATE	PRODUCTION	NP_AND_PT	Industrial Processes;Oil and Gas Production;Natural Gas Processing;Pneumatic Controllers, High Bleed >6 scfh;;
31000326	NGAS	3. Pnuematic controllers: not high or low bleed	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Natural Gas Processing;Pneumatic Controllers Intermittent Bleed;;
31000506	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Liquid Waste Treatment;Oil-Water Separation Wastewater Holding Tanks;;
31088801	BOTH	5. Fugitives	STATE	PRODUCTION	PT	Industrial Processes;Oil and Gas Production;Fugitive Emissions;Specify in Comments Field;;
31088811	BOTH	5. Fugitives	STATE	PRODUCTION	NP_AND_PT	Industrial Processes;Oil and Gas Production;Fugitive Emissions;Fugitive Emissions;;
31700101	NGAS	3. Pnuematic controllers: high or low bleed	STATE	PRODUCTION	PT	Industrial Processes;NGTS;Natural Gas Transmission and Storage Facilities;Pneumatic Controllers Low Bleed;;
39090001	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Residual Oil: Breathing Loss;;
39090002	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Residual Oil: Working Loss;;
39090003	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Distillate Oil (No. 2): Breathing Loss;;

SCC	GAS or OIL	OG_NSPS_ SCC	TOOL OR STATE	SRC_CAT	NP_PT_ NPPT	SCC_Description
39090004	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Distillate Oil (No. 2): Working Loss;;
39090005	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Oil No. 6: Breathing Loss;;
39090006	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Oil No. 6: Working Loss;;
39090007	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Methanol: Breathing Loss;;
39090008	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Methanol: Working Loss;;
39090009	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Residual Oil/Crude Oil: Breathing Loss;;
39090010	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Residual Oil/Crude Oil: Working Loss;;
39090012	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Industrial Processes;In-process Fuel Use;Fuel Storage - Fixed Roof Tanks;Dual Fuel (Gas/Oil): Working Loss;;
40301001	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Gasoline RVP 13: Breathing Loss (67000 Bbl. Tank Size);;
40301002	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Gasoline RVP 10: Breathing Loss (67000 Bbl. Tank Size);;
40301003	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Gasoline RVP 7: Breathing Loss (67000 Bbl. Tank Size);;
40301004	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Gasoline RVP 13: Breathing Loss (250000 Bbl. Tank Size);;
40301005	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Gasoline RVP 10: Breathing Loss (250000 Bbl. Tank Size);;
40301007	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Gasoline RVP 13: Working Loss (Tank Diameter Independent);;
40301008	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Gasoline RVP 10: Working Loss (Tank Diameter Independent);;
40301009	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Gasoline RVP 7: Working Loss (Tank Diameter Independent);;
40301010	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Crude Oil RVP 5: Breathing Loss (67000 Bbl. Tank Size);;

SCC	GAS or OIL	OG_NSPS_ SCC	TOOL OR STATE	SRC_CAT	NP_PT_ NPPT	SCC_Description
40301011	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Crude Oil RVP 5: Breathing Loss (250000 Bbl. Tank Size);;
40301012	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Crude Oil RVP 5: Working Loss (Tank Diameter Independent);;
40301013	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Jet Naphtha (JP-4): Breathing Loss (67000 Bbl. Tank Size);;
40301015	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Jet Naphtha (JP-4): Working Loss (Tank Diameter Independent);;
40301019	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Distillate Fuel #2: Breathing Loss (67000 Bbl. Tank Size);;
40301021	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Distillate Fuel #2: Working Loss (Tank Diameter Independent);;
40301065	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Grade 6 Fuel Oil: Breathing Loss (250000 Bbl. Tank Size);;
40301075	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Grade 6 Fuel Oil: Working Loss (Independent Tank Diameter);;
40301079	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Grade 1 Fuel Oil: Working Loss (Independent Tank Diameter);;
40301097	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Other Liquids: Breathing Loss (67000 Bbl. Tank Size);;
40301098	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Other Liquids: Breathing Loss (250000 Bbl. Tank Size);;
40301099	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fixed Roof Tanks (Varying Sizes);Other Liquids: Working Loss (Tank Diameter Independent);;
40388801	OIL	5. Fugitives	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Product Storage at Refineries;Fugitive Emissions;General;;
40400300	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and Working Tanks;Fixed Roof Tank: Flashing Loss;;
40400301	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and Working Tanks;Fixed Roof Tank: Breathing Loss;;
40400302	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and Working Tanks;Fixed Roof Tank: Working Loss;;
40400311	OIL	1. Storage Tanks	STATE	PRODUCTION	NP_AND_ PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and

SCC	GAS or OIL	OG_NSPS_SCC	TOOL OR STATE	SRC_CAT	NP_PT_NPPT	SCC_Description
						Working Tanks;Fixed Roof Tank, Condensate, working+breathing+flashing losses;;
40400312	OIL	1. Storage Tanks	STATE	PRODUCTION	NP_AND_PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and Working Tanks;Fixed Roof Tank, Crude Oil, working+breathing+flashing losses;;
40400313	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and Working Tanks;Fixed Roof Tank, Lube Oil, working+breathing+flashing losses;;
40400314	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and Working Tanks;Fixed Roof Tank, Specialty Chem-working+breathing+flashing;;
40400315	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and Working Tanks;Fixed Roof Tank, Produced Water, working+breathing+flashing;;
40400316	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Petroleum Liquids Storage (non-Refinery);Oil and Gas Field Storage and Working Tanks;Fixed Roof Tank, Diesel, working+breathing+flashing losses;;
40701613	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Organic Chemical Storage;Fixed Roof Tanks - Alkanes (Paraffins);Petroleum Distillate: Breathing Loss;;
40701614	OIL	1. Storage Tanks	STATE	PRODUCTION	PT	Chemical Evaporation;Organic Chemical Storage;Fixed Roof Tanks - Alkanes (Paraffins);Petroleum Distillate: Working Loss;;

Table 4-22. VOC reductions (tons/year) for the pt_oilgas sector after application of the Oil and Gas NSPS CONTROL packet for both analytic years 2023 and 2026

Year	Pollutant	2016v3	Emissions Reductions	% change
2023	VOC	240,361	-19,141	-8.0%
2026	VOC	240,361	-22,628	-9.4%

4.2.4.2 RICE NSPS (nonpt, ptnonipm, np_oilgas, pt_oilgas)

Packets:

CONTROL_2016_2023_RICE_NSPS_nonpt_ptnonipm_beta_platform_extended_10sep2019_v0
Control_2016_2023_RICE_NSPS_pt_oilgas_v3_platform_24aug2022_v0
Control_2016_2023_RICE_NSPS_np_oilgas_v3_platform_23aug2022_v0
Control_2016_2026_RICE_NSPS_nonpt_v2_platform_16jul2021_v0
Control_2016_2026_RICE_NSPS_pt_oilgas_v3_platform_24aug2022_v0
Control_2016_2026_RICE_NSPS_np_oilgas_v3_platform_23aug2022_v0
Control_2023_2026interp_RICE_NSPS_ptnonipm_v2_platform_MARAMA_22jul2021_v0
Control_2023_2026interp_RICE_NSPS_ptnonipm_v2_platform_noMARAMA_22jul2021_v0

Multiple sectors are affected by the RICE NSPS controls. The packet names include the sectors to which the specific packet applies. For the ptnonipm sector, 2023 packets for RICE NSPS were not needed for ptnonipm due to the approach in 2016v3 that used year 2019 non-EGU point source emissions for 2023.

The 2026 packets for ptnonipm and nonpt were developed by interpolating between the 2016v1 packets for 2023 and 2028.

For the pt_oilgas and np_oilgas sectors, year-specific RICE NSPS factors were generated for 2023 and 2026. New growth factors based on AEO2022 and state-specific production data were calculated for the oil and gas sectors which were included in the calculation of the new RICE NSPS control factors, although the actual control efficiency calculation methodology did not change from 2016v2 to 2016v3. For RICE NSPS controls, the EPA emission requirements for stationary engines differ according to whether the engine is new or existing, whether the engine is located at an area source or major source, and whether the engine is a compression ignition or a spark ignition engine. Spark ignition engines are further subdivided by power cycle, two-stroke versus four-stroke, and whether the engine is rich burn or lean burn. The NSPS reduction was applied for lean burn, rich burn and "combined" engines using Equation 4-2 and information listed in Table 4-18. Table 4-23, Table 4-24, and Table 4-28 list the SCCs for which RICE NSPS controls were applied for the 2016v3 platform. Table 4-25, Table 4-26, Table 4-27 and Table 4-29 show the reductions in emissions in the nonpoint, ptnonipm, and point and nonpoint oil and gas sectors after the application of the RICE NSPS CONTROL packet for the analytic years. Note that for nonpoint oil and gas, VOC reductions were only appropriate in the state of Pennsylvania.

Based on a state comment, the NOx emissions for facility 7667111 (Transcontinental Gas Pipeline – Station) in Virginia were further reduced to 70 tons per year following the applications of other controls.

Table 4-23. SCCs and Engine Types where RICE NSPS controls applied for nonpt and ptnonipm

SCC	Lean, Rich, or Combined	SCCDESC
20200202	Combined	Internal Combustion Engines; Industrial; Natural Gas; Reciprocating
20200253	Rich	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Rich Burn
20200254	Lean	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Lean Burn
20200256	Lean	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Clean Burn
20300201	Combined	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Reciprocating
2102006000	Combined	Stationary Source Fuel Combustion; Industrial; Natural Gas; Total: Boilers and IC Engines
2102006002	Combined	Stationary Source Fuel Combustion; Industrial; Natural Gas; All IC Engine Types
2103006000	Combined	Stationary Source Fuel Combustion; Commercial/Institutional; Natural Gas; Total: Boilers and IC Engines

Table 4-24. Non-point Oil and Gas SCCs in 2016v3 modeling platform where RICE NSPS controls applied

SCC	Lean/ Rich/ Combined	Product	Source Category	SCC_Description
2310000220	Combined	BOTH	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;All Processes;Drill Rigs;;
2310000660	Combined	BOTH	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;All Processes;Hydraulic Fracturing Engines;;
2310020600	Combined	NGAS	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas;Compressor Engines;;

SCC	Lean/ Rich/ Combined	Product	Source Category	SCC_Description
2310021202	Lean	NGAS	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Natural Gas Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP;;
2310021251	Lean	NGAS	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Lateral Compressors 4 Cycle Lean Burn;;
2310021302	Rich	NGAS	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP;;
2310021351	Rich	NGAS	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Lateral Compressors 4 Cycle Rich Burn;;
2310023202	Lean	CBM	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP;;
2310023251	Lean	CBM	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Lateral Compressors 4 Cycle Lean Burn;;
2310023302	Rich	CBM	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP;;
2310023351	Rich	CBM	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Lateral Compressors 4 Cycle Rich Burn;;
2310300220	Combined	NGAS	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;All Processes - Conventional;Drill Rigs;;
2310400220	Combined	BOTH	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;All Processes - Unconventional;Drill Rigs;;

Table 4-25. Nonpoint Emissions reductions after the application of the RICE NSPS

year	Poll	2016v3 (tons)	Emissions reductions (tons)	% change
2023	CO	1,939,947	-20,440	-1.1%
2023	NOX	750,215	-30,573	-4.1%
2026	CO	1,939,947	-25,283	-1.3%
2026	NOX	750,215	-38,855	-5.2%

Table 4-26. Ptnonipm Emissions reductions after the application of the RICE NSPS

year	poll	2023gf (tons)	Emissions reductions (tons)	% change
2026	CO	1,359,690	-85	-0.01%
2026	NOX	848,409	-142	-0.02%
2026	VOC	759,289	-0.5	0.00%

Table 4-27. Oil and Gas Emissions reductions for np_oilgas sector due to application of RICE NSPS

year	Poll	2016v3	2016pre-CoST emissions	Emissions reduction	% change
2023	CO	765,734	767,969	-93,051	-12.1%
2023	NOX	587,919	610,402	-86,508	-14.2%
2023	VOC	2,543,889	2,591,022	-463	0.0%
2026	CO	765,734	767,969	-105,028	-13.7%
2026	NOX	587,919	610,402	-100,126	-16.4%
2026	VOC	2,543,889	2,591,022	-513	0.0%

Table 4-28. Point source SCCs in pt_oilgas sector where RICE NSPS controls applied.

SCC	Lean, Rich, or Combined	SCCDESC
20200202	Combined	Internal Combustion Engines; Industrial; Natural Gas; Reciprocating
20200253	Rich	Internal Combustion Engines; Industrial; Natural Gas;4-cycle Rich Burn
20200254	Lean	Internal Combustion Engines; Industrial; Natural Gas;4-cycle Lean Burn
20200256	Combined	Internal Combustion Engines; Industrial; Natural Gas;4-cycle Clean Burn
20300201	Combined	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Reciprocating
31000203	Combined	Industrial Processes; Oil and Gas Production; Natural Gas Production; Compressors (See also 310003-12 and -13)

Table 4-29. Emissions reductions (tons/year) in pt_oilgas sector after the application of the RICE NSPS CONTROL packet for analytic years 2023 and 2026.

Year	Pollutant	2016v3	Emissions Reductions	% change
2023	CO	205,468	-23,724	-11.5%
2023	NOX	414,623	-58,080	-14.0%
2023	VOC	240,361	-279	-0.1%
2026	CO	205,468	-29,200	-14.2%
2026	NOX	414,623	-69,120	-16.7%
2026	VOC	240,361	-313	-0.1%

4.2.4.3 Fuel Sulfur Rules (nonpt, ptnonipm)

Packets:

Control_2016_202X_MANEVU_Sulfur_fromMARAMA_v1_platform_22aug2022_nf_v1

The control packet for fuel sulfur rules is the same for all analytic years. Fuel sulfur rules controls are reflected for the following states: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Rhode Island, and Vermont. The fuel limits for these states are incremental starting after year 2012, but are fully implemented by July 1, 2018, in these states. The control packet representing these controls was updated by MARAMA for the 2016v1 platform. For 2016v3, states that had fully implemented their controls by 2017 were removed (namely Delaware, New York, and Pennsylvania) because 2017 NEI was used for nonpoint emissions.

Summaries of the sulfur rules by state, with emissions reductions relative to the entire sector emissions and relative to the analytic year emissions for the affected SCCs are provided in Table 4-30, which reflects the impacts of the MARAMA packet only, as these reductions are not estimated in non-MARAMA states. A negligible amount of reductions occur in the pt_oilgas sector. Note that ptnonipm sources are not impacted in 2016v3 platform since the starting point for the 2023 emissions was the 2019 NEI.

Table 4-30. Summary of fuel sulfur rule impacts on nonpoint SO2 emissions for 2023

Pollutant	State	2023 pre-control Emissions (tons)	2023 post-control Emissions (tons)	Change in emissions (tons)	Percent change
NOX	Connecticut	3,691	3,424	-268	-7.2%
NOX	Maine	6,502	6,150	-353	-5.4%
NOX	Massachusetts	9,391	8,887	-504	-5.4%
NOX	New Hampshire	6,480	6,223	-257	-4.0%
NOX	Rhode Island	879	814	-65	-7.4%
NOX	Vermont	878	798	-80	-9.1%
NOX	**Six state total**	**27,822**	**26,296**	**-1,526**	**-5.5%**
SO2	Connecticut	1,412	82	-1,330	-94.2%
SO2	Maine	1,220	35	-1,185	-97.1%
SO2	Massachusetts	2,251	88	-2,163	-96.1%
SO2	New Hampshire	4,142	21	-4,121	-99.5%
SO2	Rhode Island	359	38	-320	-89.3%
SO2	Vermont	399	26	-374	-93.6%
SO2	**Six state total**	**9,783**	**290**	**-9,493**	**-97.0%**
SO2	**ALL state total**	**167,817**	**158,324**	**-9,493**	**-5.6%**

4.2.4.4 Natural Gas Turbines NO_x NSPS (ptnonipm, pt_oilgas)

Packets:

Control_2016_2023_NG_Turbines_NSPS_pt_oilgas_v3_platform_24aug2022_v0
Control_2023_2026interp_NG_Turbines_NSPS_ptnonipm_v2_platform_MARAMA_22jul2021_v0
Control_2023_2026interp_NG_Turbines_NSPS_ptnonipm_v2_platform_nonMARAMA_22jul2021_v0
Control_2016_2026_NG_Turbines_NSPS_pt_oilgas_v3_platform_24aug2022_v0

For ptnonipm, the packets for 2023 were reused from the 2016v1 platform; the packets for 2026 were interpolated between the 2023 and 2028 packets for the 2016v1 platform. For pt_oilgas, the packets for 2016v3 are based on updated growth information for that sector from state-historical production data and the AEO2022 production forecast database. The new growth factors were to calculate the new control efficiencies for all analytic years (2023 and 2026). The control efficiency calculation methodology did not change from 2016v2 to 2016v3 modeling platform.

Natural Gas Turbines NSPS controls were generated based on examination of emission limits for stationary combustion turbines that are not in the power sector. In 2006, the EPA promulgated standards of performance for new stationary combustion turbines in 40 CFR part 60, subpart KKKK. The standards reflect changes in NOx emission control technologies and turbine design since standards for these units were originally promulgated in 40 CFR part 60, subpart GG. The 2006 NSPSs affecting NO_x and SO_2 were established at levels that bring the emission limits up-to-date with the performance of current combustion turbines. Stationary combustion turbines were also regulated by the NOx State Implementation Plan (SIP) Call, which required affected gas turbines to reduce their NOx emissions by 60 percent. Table 4-31compares the 2006 NSPS emission limits with the NO_x Reasonably Available Control Technology (RACT) regulations in selected states within the NO_x SIP Call region. More information on the NOx SIP call is available at: https://www.epa.gov/csapr/final-update-nox-sip-call-regulations-emissions-monitoring-provisions-state-implementation. The state NO_x RACT regulations summary (Pechan, 2001) is from a year 2001 analysis, so some states may have updated their rules since that time.

Table 4-31. Stationary gas turbines NSPS analysis and resulting emission rates used to compute controls

NOx Emission Limits for New Stationary Combustion Turbines				
Firing Natural Gas	<50 MMBTU/hr	50-850 MMBTU/hr	>850 MMBTU/hr	
Federal NSPS	100	25	15	Ppm
State RACT Regulations	5-100 MMBTU/hr	100-250 MMBTU/hr	>250 MMBTU/hr	
Connecticut	225	75	75	Ppm
Delaware	42	42	42	Ppm
Massachusetts	65*	65	65	Ppm
New Jersey	50*	50	50	Ppm
New York	50	50	50	Ppm
New Hampshire	55	55	55	Ppm
* Only applies to 25-100 MMBTU/hr				
Notes: The above state RACT table is from a 2001 analysis. The current NY State regulations have the same emission limits.				
New source emission rate (Fn)			NO_X ratio (Fn)	Control (%)
NOx SIP Call states plus CA	= 25 / 42 =		0.595	40.5%
Other states	= 25 / 105 =		0.238	76.2%

For control factor development, the existing source emission ratio was set to 1.0 for combustion turbines. The new source emission ratio for the NOx SIP Call states and California is the ratio of state NOx emission limit to the Federal NSPS. A complicating factor in the above is the lack of size information in the stationary source SCCs. Plus, the size classifications in the NSPS do not match the size differentiation used in state air emission regulations. We accepted a simplifying assumption that most industrial applications of combustion turbines are in the 100-250 MMBtu/hr size range and computed the new source emission rates as the NSPS emission limit for 50-850 MMBtu/hr units divided by the state emission limits. We used a conservative new source emission ratio by using the lowest state emission limit of 42 ppmv (Delaware). This yields a new source emission ratio of 25/42, or 0.595 (40.5 percent reduction) for states with existing combustion turbine emission limits. States without existing turbine NOx limits would have a lower new source emission ratio: the uncontrolled emission rate (105 ppmv via

AP-42) divided into 25 ppmv = 0.238 (76.2 percent reduction). This control was then plugged into Equation 4-2 as a function of the year-specific projection factor. Also, Natural Gas Turbines control factors supplied by MARAMA were used within the MARAMA region for 2023 and 2026.

Table 4-32 and Table 4-34 list the point source SCCs where Natural Gas Turbines NSPS controls were applied for the 2016v1 platform. Table 4-33 and Table 4-35 show the reduction in NOx emissions after the application of the Natural Gas Turbines NSPS CONTROL packet to the analytic years. The values in Table 4-33 and Table 4-35 include emissions both inside and outside the MARAMA region.

Table 4-32. Ptnonipm SCCs in 2016v1 modeling platform where Natural Gas Turbines NSPS controls applied

SCC	SCC Description
20200201	Internal Combustion Engines; Industrial; Natural Gas; Turbine
20200203	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Cogeneration
20200209	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Exhaust
20200701	Internal Combustion Engines; Industrial; Process Gas; Turbine
20200714	Internal Combustion Engines; Industrial; Process Gas; Turbine: Exhaust
20300203	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine: Cogeneration

Table 4-33. Ptnonipm emissions reductions after the application of the Natural Gas Turbines NSPS

year	Poll	2023gf (tons)	emissions reduction (tons)	% change
2026	NOX	848,409	-334	-0.04%

Table 4-34. Point source SCCs in pt_oilgas sector where Natural Gas Turbines NSPS control applied.

SCC	**SCC description**
20200201	Internal Combustion Engines; Industrial; Natural Gas; Turbine
20200209	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Exhaust
20300202	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine
20300209	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine: Exhaust
20200203	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Cogeneration
20200714	Internal Combustion Engines; Industrial; Process Gas; Turbine: Exhaust
20300203	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine: Cogeneration

Table 4-35. Emissions reductions (tons/year) for pt_oilgas after the application of the Natural Gas Turbines NSPS CONTROL packet for analytic years.

Year	**Pollutant**	**2016v3**	**Emissions Reduction**	**% change**
2023	NOX	414,623	-12,132	-2.9%
2026	NOX	414,623	-13,648	-3.3%

4.2.4.5 Process Heaters NO_x NSPS (ptnonipm, pt_oilgas)

Packets:

Control_2023_2026interp_Process_Heaters_NSPS_ptnonipm_v2_platform_22jul2021_v0
Control_2016_2023_Process_Heaters_NSPS_pt_oilgas_v3_platform_24aug2022_v0
Control_2016_2026_Process_Heaters_NSPS_pt_oilgas_v3_platform_24aug2022_v0

For ptnonipm, no additional controls for process heaters were applied to the 2023 emissions; the packet for 2023 to 2026 was developed based on an interpolation between the 2023 and 2028 factors for the 2016v1 platform. For pt_oilgas, the packets were newly developed for 2016v3 based on updated information.

Process heaters are used throughout refineries and chemical plants to raise the temperature of feed materials to meet reaction or distillation requirements. Fuels are typically residual oil, distillate oil, refinery gas, or natural gas. In some sense, process heaters can be considered as emission control devices because they can be used to control process streams by recovering the fuel value while destroying the VOC. The criteria pollutants of most concern for process heaters are NO_x and SO_2. In 2016, it is assumed that process heaters have not been subject to regional control programs like the NOx SIP Call, so most of the emission controls put in-place at refineries and chemical plants have resulted from RACT regulations that were implemented as part of SIPs to achieve ozone NAAQS in specific areas, and refinery consent decrees. The boiler/process heater NSPS established NOx emission limits for new and modified process heaters. These emission limits are displayed in Table 4-36.

Table 4-36. Process Heaters NSPS analysis and 2016v1 new emission rates used to estimate controls

NO_X emission rate Existing PPMV (=Fe)	**Natural Draft (fraction)**	**Forced Draft (fraction)**	**Average**
80	0.4	0	
100	0.4	0.5	
150	0.15	0.35	
200	0.05	0.1	
240	0	0.05	
Cumulative, weighted (=Fe)	104.5	134.5	119.5
NSPS Standard	40	60	
New Source NO_X ratio (=Fn)	0.383	0.446	**0.414**
NSPS Control (%)	61.7	55.4	58.6

For computations, the existing source emission ratio (Fe) was set to 1.0. The computed (average) NO_x emission factor ratio for new sources (Fn) is 0.41 (58.6 percent control). The retirement rate is the inverse of the expected unit lifetime. There is limited information in the literature about process heater lifetimes. This information was reviewed at the time that the Western Regional Air Partnership (WRAP) developed its initial regional haze program emission projections, and energy technology models used a 20-year lifetime for most refinery equipment. However, it was noted that in practice, heaters would probably have a lifetime that was on the order of 50 percent above that estimate. Therefore, a 30-year lifetime was used to estimate the effects of process heater growth and retirement. This yields a 3.3 percent retirement rate. This control was then plugged into Equation 4-2 as a function of the year-specific projection factor. Table

4-37 and Table 4-39 list the point source SCCs where Process Heaters NSPS controls were applied for the 2016v1 platform. Table 4-38 and Table 4-40 show the reduction in NOx emissions after the application of the Process Heaters NSPS CONTROL packet for the analytic years.

Table 4-37. Ptnonipm SCCs in 2016v1 modeling platform where Process Heaters NSPS controls applied.

SCC	SCC Description
30190003	Industrial Processes; Chemical Manufacturing; Fuel Fired Equipment; Process Heater: Natural Gas
30190004	Industrial Processes; Chemical Manufacturing; Fuel Fired Equipment; Process Heater: Process Gas
30590002	Industrial Processes; Mineral Products; Fuel Fired Equipment; Residual Oil: Process Heaters
30590003	Industrial Processes; Mineral Products; Fuel Fired Equipment; Natural Gas: Process Heaters
30600101	Industrial Processes; Petroleum Industry; Process Heaters; Oil-fired
30600102	Industrial Processes; Petroleum Industry; Process Heaters; Gas-fired
30600103	Industrial Processes; Petroleum Industry; Process Heaters; Oil
30600104	Industrial Processes; Petroleum Industry; Process Heaters; Gas-fired
30600105	Industrial Processes; Petroleum Industry; Process Heaters; Natural Gas-fired
30600106	Industrial Processes; Petroleum Industry; Process Heaters; Process Gas-fired
30600107	Industrial Processes; Petroleum Industry; Process Heaters; Liquified Petroleum Gas (LPG)
30600199	Industrial Processes; Petroleum Industry; Process Heaters; Other Not Classified
30990003	Industrial Processes; Fabricated Metal Products; Fuel Fired Equipment; Natural Gas: Process Heaters
31000401	Industrial Processes; Oil and Gas Production; Process Heaters; Distillate Oil (No. 2)
31000402	Industrial Processes; Oil and Gas Production; Process Heaters; Residual Oil
31000403	Industrial Processes; Oil and Gas Production; Process Heaters; Crude Oil
31000404	Industrial Processes; Oil and Gas Production; Process Heaters; Natural Gas
31000405	Industrial Processes; Oil and Gas Production; Process Heaters; Process Gas
31000406	Industrial Processes; Oil and Gas Production; Process Heaters; Propane/Butane
31000413	Industrial Processes; Oil and Gas Production; Process Heaters; Crude Oil: Steam Generators
31000414	Industrial Processes; Oil and Gas Production; Process Heaters; Natural Gas: Steam Generators
31000415	Industrial Processes; Oil and Gas Production; Process Heaters; Process Gas: Steam Generators
39900501	Industrial Processes; Miscellaneous Manufacturing Industries; Process Heater/Furnace; Distillate Oil
39900601	Industrial Processes; Miscellaneous Manufacturing Industries; Process Heater/Furnace; Natural Gas
39990003	Industrial Processes; Miscellaneous Manufacturing Industries; Miscellaneous Manufacturing Industries; Natural Gas: Process Heaters

Table 4-38. Ptnonipm emissions reductions after the application of the Process Heaters NSPS

year	pollutant	2023gf (tons)	emissions reduction (tons)	% change
2026	NOX	848,409	-2,202	-0.3%

Table 4-39. Point source SCCs in pt_oilgas sector where Process Heaters NSPS controls were applied

SCC	SCC Description
30190003	Industrial Processes; Chemical Manufacturing; Fuel Fired Equipment; Process Heater: Natural Gas
30600102	Industrial Processes; Petroleum Industry; Process Heaters; Gas-fired
30600104	Industrial Processes; Petroleum Industry; Process Heaters; Gas-fired
30600105	Industrial Processes; Petroleum Industry; Process Heaters; Natural Gas-fired
30600106	Industrial Processes; Petroleum Industry; Process Heaters; Process Gas-fired
30600199	Industrial Processes; Petroleum Industry; Process Heaters; Other Not Classified
30990003	Industrial Processes; Fabricated Metal Products; Fuel Fired Equipment; Natural Gas: Process Heaters
31000401	Industrial Processes; Oil and Gas Production; Process Heaters; Distillate Oil (No. 2)
31000402	Industrial Processes; Oil and Gas Production; Process Heaters; Residual Oil
31000403	Industrial Processes; Oil and Gas Production; Process Heaters; Crude Oil
31000404	Industrial Processes; Oil and Gas Production; Process Heaters; Natural Gas
31000405	Industrial Processes; Oil and Gas Production; Process Heaters; Process Gas
31000413	Industrial Processes; Oil and Gas Production; Process Heaters; Crude Oil: Steam Generators
31000414	Industrial Processes; Oil and Gas Production; Process Heaters; Natural Gas: Steam Generators
31000415	Industrial Processes; Oil and Gas Production; Process Heaters; Process Gas: Steam Generators
39900501	Industrial Processes; Miscellaneous Manufacturing Industries; Process Heater/Furnace; Distillate Oil
39900601	Industrial Processes; Miscellaneous Manufacturing Industries; Process Heater/Furnace; Natural Gas

Table 4-40. NOx emissions reductions (tons/year) in pt_oilgas sector after the application of the Process Heaters NSPS CONTROL packet for analytics years.

Year	Pollutant	2016v3	Emissions Reduction	% change
2023	NOX	414,623	-2,234	-0.5%
2026	NOX	414,623	-2,520	-0.6%

4.2.4.6 Ozone Transport Commission Rules (nonpt, solvents)

Packets:

Control_2016_202X_solvents_OTC_v3_platform_MARAMA_30jun2022_v0
Control_2016_202X_nonpt_PFC_v1_platform_MARAMA_04oct2019_v1

Several MARAMA states have adopted rules reflecting the recommendations of the Ozone Transport Commission (OTC) for reducing VOC emissions from consumer products, architectural and industrial maintenance coatings, and various other solvents. The rules affected 27 different SCCs in the surface coatings (2401xxxxxx), degreasing (2415000000), graphic arts (2425010000), miscellaneous industrial (2440020000), and miscellaneous non-industrial consumer and commercial (246xxxxxxx) categories. The packet applies only to MARAMA states and not all states adopted all rules. This packet applies to emissions in the new solvents sector. The new SCCs in the solvents sector were added to the packet.

The OTC also developed a model rule to address VOC emissions from portable fuel containers (PFCs) via performance standards and phased-in PFC replacement that was implemented in two phases. Some states adopted one or both phases of the OTC rule, while others relied on the Federal rule. MARAMA calculated control factors to reflect each state's compliance dates and, where states implemented one or both phases of the OTC requirements prior to the Federal mandate, accounted for the early reductions in the control factors. The rules affected permeation, evaporation, spillage, and vapor displacement for residential (2501011xxx) and commercial (2501012xxx) portable gas can SCCs. This packet applies to the nonpt sector.

MARAMA provided control packets to apply the solvent and PFC rule controls. The 2016v1 PFC packet is reused and the same for all years. For 2016v3, the OTC solvents packet was updated to include new controls in Delaware and New York based on comments from those states.

4.3 Projections Computed Outside of CoST

Projections for sectors not calculated using CoST are discussed in this section.

4.3.1 Nonroad Mobile Equipment Sources (nonroad)

Outside of California and Texas, the MOVES3 model was run separately for each analytic year, including 2023 and 2026, resulting in a separate inventory for each year. The fuels used are specific to each analytic year, but the meteorological data represented the year 2016. The 2023 and 2026 nonroad emissions include all nonroad control programs finalized as of the date of the MOVES3.0.0 release, including most recently:

- Emissions Standards for New Nonroad Spark-Ignition Engines, Equipment, and Vessels: October 2008 (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-nonroad-spark-ignition);
- Growth and control from Locomotives and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder: March 2008 (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-air-pollution-locomotive); and
- Clean Air Nonroad Diesel Final Rule – Tier 4: May 2004 (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-air-pollution-nonroad-diesel).

The resulting analytic year inventories were processed into the format needed by SMOKE in the same way as the base year emissions.

Inside California and Texas, CARB and TCEQ provided separate datasets for various analytic years. For 2016v3, CARB provided new nonroad inventories for 2023 and 2026. The TCEQ inventories from 2016v1 and 2016v2 were reused in 2016v3, including a 2023 dataset, and a 2026 dataset interpolated from TCEQ-provided 2023 and 2028 inventories. VOC and $PM_{2.5}$ by speciation profile, and VOC HAPs, were added to all analytic year California and Texas nonroad inventories using the same procedure as for the 2016 inventory, but based on the analytic year MOVES runs instead of the 2016 MOVES run.

4.3.2 Onroad Mobile Sources (onroad)

For 2016v2, MOVES3 was run separately for 2023 and 2026, resulting in separate emission factors for each year. The 2023 and 2026 onroad emission factors account for changes in activity data and the impact of on-the-books rules that are implemented into MOVES3. These include regulations such as:

- Safer Affordable Fuel Efficient (SAFE) Vehicles Final Rule for Model Years 2021-2026 (March 2020);
- Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles – Phase 2 (October 2016);
- Tier 3 Vehicle Emission and Fuel Standards Program (March 2014) (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-motor-vehicles-tier-3);
- 2017 and Later Model Year Light-Duty Vehicle GHG Emissions and Corporate Average Fuel Economy Standards (October 2012);
- Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles (September 2011);
- Regulation of Fuels and Fuel Additives: Modifications to Renewable Fuel Standard Program (RFS2) (December 2010); and
- Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards Final Rule for Model-Year 2012-2016 (May 2010).

Local inspection and maintenance (I/M) and other onroad mobile programs are included such as: California LEVIII, the National Low Emissions Vehicle (LEV) and Ozone Transport Commission (OTC); LEV regulations, local fuel programs, and Stage II refueling control programs. Note that MOVES3 emission rates for model years 2017 and beyond are equivalent to CA LEVIII rates for NOx and VOC. Therefore, it was not necessary to update the rates used for states that have adopted the rules in the 2020s. The emission factors used for 2016v2 and 2016v3 were the same except for combination long haul trucks. For 2016v3, MOVES3 was run for combination long haul trucks only for 2023 and 2026 using an updated age distribution and the resulting emission factors were used. For 2016v3, representative county assignments were adjusted in three North Carolina counties (Lee, Onslow, and Rockingham) to reflect changes in inspection and maintenance programs in those counties. Also, to reflect changes in inspection and maintenance programs in Tennessee, MOVES was rerun for three representative counties in that state (Davidson, Hamilton, and Rutherford).

The fuels used are specific to each analytic year, the age distributions were projected to the analytic year, and the meteorological data represented the year 2016. The resulting emission factors were combined with analytic year activity data using SMOKE-MOVES run in a similar way as the base year. The development of the analytic year activity data is described later in this section. CARB provided separate emissions datasets for each analytic year. The CARB-provided emissions for 2023 and 2026 were adjusted to match the temporal and spatial patterns of the SMOKE-MOVES based emissions.

An update in 2016v3 was to apply adjustment factors to reflect the impacts of the light duty greenhouse gas rule finalized in the Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards, 86 FR 74434 (December 30, 2021)[42]. The adjustment factors that reflect the impacts of the rule on CAPs are shown in Table 4-41. These adjustment factors are intended to represent not only the effects of the rule on onroad emissions in 2023 and 2026, but also ancillary effects on stationary emissions such as increased electricity production for electric vehicles.

Table 4-41. Light duty greenhouse gas rule adjustments for 2023 and 2026 onroad emissions

Year	Source Type	Fuel Type	CO	VOC	NOx	SO2	PM
2023	Light Truck	Diesel	-0.04%	-0.01%	0.83%	12.42%	1.29%
2023	Light Truck	E85	0.12%	0.10%	0.52%	35.07%	1.10%
2023	Light Truck	Gasoline	0.06%	-0.40%	0.24%	10.77%	-0.04%
2023	Passenger Car	Diesel	0.44%	0.59%	1.16%	48.83%	1.39%
2023	Passenger Car	E85	0.49%	0.78%	1.55%	92.53%	2.57%
2023	Passenger Car	Gasoline	0.30%	0.00%	0.43%	7.17%	0.10%
2026	Light Truck	Diesel	-4.46%	-14.23%	-10.62%	-15.77%	-19.70%
2026	Light Truck	E85	0.63%	0.94%	3.12%	225.12%	6.88%
2026	Light Truck	Gasoline	0.14%	-2.37%	1.28%	65.92%	1.02%
2026	Passenger Car	Diesel	2.05%	2.47%	4.81%	206.91%	5.12%
2026	Passenger Car	E85	1.83%	2.90%	5.92%	373.97%	9.77%
2026	Passenger Car	Gasoline	0.72%	-1.86%	0.67%	25.86%	-1.20%

Analytic year 2023 and 2026 VMT were developed as follows:

- VMT were projected from 2016 to 2019 using VMT data from the FHWA county-level VM-2 reports. At the time of this study, these reports were available for each year up through 2019. As with the original 2016 backcast, EPA calculated county-road type factors based on FHWA VM-2 county-level data for each of the three years, and county total factors were applied instead of county-road factors in states with significant changes in road type classifications from year to year.
- Total VMT were held flat from 2019 to 2021 to reflect impacts from the COVID-19 pandemic. For 2021, VMT was re-split by fuel type according to fuel splits from the 2020NEI VMT. During this step, VMT totals by county, source type, and road type were preserved, but fuel splits from 2020NEI were applied and the percentage of electric vehicles increased as a result.
- VMT were then projected from 2021 to 2023 using AEO2022.

[42] https://www.govinfo.gov/content/pkg/FR-2021-12-30/pdf/2021-27854.pdf

- VMT data submitted by state and local agencies for the year 2023 for the 2016v1 platform were incorporated where available, in place of the EPA default 2023 projection. The following states or agencies submitted 2023 VMT: Connecticut, Georgia, Massachusetts, New Jersey, North Carolina, Ohio, Wisconsin, Louisville metro (KY/IN), Pima County AZ, and Clark County NV.
- The resulting 2023 VMT data, including VMT submitted by local agencies, were projected to 2026 using AEO2022. Thus the 2026 projected VMT used 2023 as the baseline and incorporated submitted 2023 VMT.

Annual VMT data from the AEO2022 reference case by fuel and vehicle type were used to project VMT from 2021 to the projection years. Specifically, the following two AEO2021 tables were used:

- Light Duty (LD): Light-Duty VMT by Technology Type (table #41): https://www.eia.gov/outlooks/aeo/data/browser/#/?id=51-AEO2021&sourcekey=0
- Heavy Duty (HD): Freight Transportation Energy Use (table #49): https://www.eia.gov/outlooks/aeo/data/browser/#/?id=58-AEO2021&cases=ref2021~aeo2020ref&sourcekey=0

To develop the VMT projection factors, total VMT for each MOVES fuel and vehicle grouping was calculated for the years 2021, 2023, and 2026 based on the AEO-to-MOVES mappings above. From these totals, 2021-2023 and 2023-2026 VMT trends were calculated for each fuel and vehicle grouping. Those trends became the national VMT projection factors. The AEO2022 tables include data starting from the year 2021. MOVES fuel and vehicle types were mapped to AEO fuel and vehicle classes. The resulting 2021-to-analytic year national VMT projection factors used for the 2016v3 platform are provided in Table 4-42. These factors were adjusted to prepare county-specific projection factors for light duty vehicles based on human population data available from the BenMAP model by county for the years 2023 and 2026[43] (https://www.woodsandpoole.com/, circa 2015). The purpose of this adjustment based on population changes helps account for areas of the country that are growing more than others.

Table 4-42. Factors used to Project VMT to analytic years

SCC6	description	2021 to 2023 factor	2023 to 2026 factor
220111	LD gas	1.08	1.05
220121	LD gas	1.08	1.05
220131	LD gas	1.08	1.05
220132	LD gas	1.08	1.05
220141	Buses gas	1.03	1.05
220142	Buses gas	1.03	1.05
220143	Buses gas	1.03	1.05
220151	MHD gas	1.03	1.05
220152	MHD gas	1.03	1.05
220153	MHD gas	1.03	1.05
220154	MHD gas	1.03	1.05

[43] The final year of the population dataset used is 2030

SCC6	description	2021 to 2023 factor	2023 to 2026 factor
220161	HHD gas	0.80	0.77
220221	LD diesel	1.09	1.05
220231	LD diesel	1.09	1.05
220232	LD diesel	1.09	1.05
220241	Buses diesel	1.04	1.04
220242	Buses diesel	1.04	1.04
220243	Buses diesel	1.04	1.04
220251	MHD diesel	1.04	1.04
220252	MHD diesel	1.04	1.04
220253	MHD diesel	1.04	1.04
220254	MHD diesel	1.04	1.04
220261	HHD diesel	1.04	1.03
220262	HHD diesel	1.04	1.03
220341	Buses CNG	1.06	1.02
220342	Buses CNG	1.06	1.02
220343	Buses CNG	1.06	1.02
220351	MHD CNG	1.06	1.02
220352	MHD CNG	1.06	1.02
220353	MHD CNG	1.06	1.02
220354	MHD CNG	1.06	1.02
220361	HHD CNG	1.04	1.00
220521	LD E-85	1.02	0.93
220531	LD E-85	1.02	0.93
220532	LD E-85	1.02	0.93
220921	LD Electric	1.83	1.83
220931	LD Electric	1.83	1.83
220932	LD Electric	1.83	1.83

In areas where the EPA default analytic year VMT projection were used, analytic year VPOP data were projected using calculations of VMT/VPOP ratios for each county, based on 2017 NEI with MOVES3 fuels splits. Those ratios were then applied to the analytic year projected VMT to estimate analytic year VPOP. Analytic year VPOP data submitted by state and local agencies were incorporated into the VPOP projections for 2023. Analytic year VPOP data for 2023 were provided by state and local agencies in NH, NJ, NC, WI, Pima County, AZ, and Clark County, NV. In addition, 2023 VPOP was carried forward from the 2016v1 platform in CT, GA, MA, and the Louisville metro areas; as those areas only submitted VMT for 2023 and not VPOP, but keeping the 2016v1 VPOP in those areas ensures consistency between the VMT and VPOP. Additionally, North Carolina bus VMT and VPOP (based on EPA defaults) was carried forward from the 2016v1 platform so that all VMT and VPOP in North Carolina would be the same as 2016v1. Both VMT and VPOP were redistributed between the light duty car and truck vehicle types (21/31/32) based on light duty vehicle splits from the EPA computed default projection.

Hoteling hours were projected to the analytic years by calculating 2016 inventory HOTELING/VMT ratios for each county for combination long-haul trucks on restricted roads only. Those ratios were then applied to the analytic year projected VMT for combination long-haul trucks on restricted roads to calculate analytic year hoteling. Some counties had hoteling activity but did not have combination long-haul truck restricted road VMT in 2016; in those counties, the national AEO-based projection factor for diesel combination trucks was used to project 2016 hoteling to the analytic years. This procedure gives county-total hoteling for the analytic years. Each analytic year also has a distinct APU percentage based on MOVES input data that was used to split county total hoteling to each SCC: 12.91% APU for 2023, and 20.46% for 2026 . New Jersey provided 2023 hoteling data for 2016v1 and those data were used for the 2016v3 platform although the new APU fraction for MOVES3 2023 (12.91%) was incorporated. As in the 2016 backcast, for counties that had 2017 hoteling hours, but do not have vehicle type 62 VMT on restricted road type (i.e., counties that should have hoteling, but do not have any VMT to calculate it from) we projected 2016 to 2019 using the FHWA-based county total 2016 to 2019 trend, and then used the AEO-based factors for heavy duty diesel to project beyond 2019.

Analytic year starts were calculated using 2017NEI-based VMT ratios, similar to how 2016 starts were calculated:

Analytic year STARTS = Analytic year VMT * (2017 STARTS / 2017 VMT by county+SCC6)

Analytic year ONI activity was calculated using a similar formula, but with 2016-based ratios rather than 2017-based ratios, in order to reflect the new method used to calculate ONI activity for 2016:

Analytic year ONI = Analytic year VMT * (2016 ONI / 2016 VMT by county+SCC6)

In California, onroad emissions in SMOKE-MOVES are adjusted to match CARB-provided data using the same procedure described in Section 2.3.3. For 2016v3 platform, CARB provided new EMFAC2017-based emissions for 2023 and 2026.

4.3.3 Locomotives (rail, ptnonipm)

Outside of California, for 2023, rail emissions are unchanged from 2016v1, including rail yards (which already included the Georgia-provided update for 2023 in 2016v1). Rail emissions for 2026 were interpolated from the 2023 and 2028 emissions in 2016v1. Factors to compute emissions for analytic year of 2030 were based on analytic year fuel use values from the Energy Information Administration’s 2018 Annual Energy Outlook (AEO) freight rail energy use growth rate projections for 2016 thru 2030 (see Table 4-43) and emission factors based on historic emissions trends that reflect the rate of market penetration of new locomotive engines.

For 2016v3, CARB provided new locomotive emissions for 2023 and 2026. In addition to updating the nonpoint rail inventory in California, the point rail yard emissions in ptnonipm were also updated to better reflect the new rail yard emissions in the California rail inventory.

A correction factor was added to adjust the AEO projected fuel use for 2017 to match the actual 2017 R-1 fuel use data. The additive effect of this correction factor was carried forward for each subsequent year from 2018 thru 2030. The modified AEO growth rates were used to calculate analytic year Class I line-haul fuel use totals for 2020, 2023, 2026, and 2030. As shown in Table 4-43 the analytic year fuel use values ranged between 3.2 and 3.4 billion gallons, which matched up well with the long-term line-haul fuel use trend between 2005 and 2018. The emission factors for NOx, PM10 and VOC were derived from trend lines based on historic line-haul emission factors from the period of 2007 through 2017.

Table 4-43. Class I Line-haul Fuel Projections based on 2018 AEO Data

Year	AEO Freight Factor	Projection Factor	Corrected AEO Fuel	Raw AEO Fuel
2016	1	1	**3,203,595,133**	**3,203,595,133**
2017	1.0212	1.0346	3,314,384,605	3,271,393,249
2018	1.0177	1.0311	*3,303,215,591*	3,260,224,235
2019	1.0092	1.0226	*3,275,939,538*	3,232,948,182
2020	1.0128	1.0262	*3,287,479,935*	3,244,488,580
2021	1.0100	1.0235	*3,278,759,301*	3,235,767,945
2022	0.9955	1.0090	*3,232,267,591*	3,189,276,235
2023	0.9969	1.0103	*3,236,531,624*	3,193,540,268
2024	1.0221	1.0355	*3,317,383,183*	3,274,391,827
2025	1.0355	1.0489	*3,360,367,382*	3,317,376,026
2026	1.0410	1.0544	*3,377,946,201*	3,334,954,845
2027	1.0419	1.0553	*3,380,697,189*	3,337,705,833
2028	1.0356	1.0490	*3,360,491,175*	3,317,499,820
2029	1.0347	1.0529	*3,373,114,601*	3,314,913,891
2030	1.0319	1.0561	*3,383,235,850*	3,305,890,648

The projected fuel use data was combined with the emission factor estimates to create analytic year link-level emission inventories based on the MGT traffic density values contained in the FRA's 2016 shapefile. The link-level data created for 2020, 2023, 2026 and 2030 were aggregated to create county, state, and national emissions estimates (see Table 4-44) which were then converted into FF10 format for use in the 2016 emissions platforms.

Table 4-44. Class I Line-haul Historic and Analytic Year Projected Emissions

Inventory	CO	HC	NH3	NOx	PM10	PM2.5	SO2
2007 (2008 NEI)	110,969	37,941	347	754,433	25,477	23,439	7,836
2014 NEI	107,995	29,264	338	609,295	19,675	18,101	381
2016 v2	96,068	22,991	301	492,999	14,351	13,889	427
2017 NEI	97,272	21,560	304	492,385	14,411	13,979	343
2023 Projected	97,514	17,265	305	403,207	10,816	10,477	431
2026 Projected	99,840	15,524	312	375,121	9,714	9,412	438
2030 Projected	99,338	12,512	311	349,868	8,014	7,766	436

Other rail emissions were projected based on AEO growth rates as shown in Table 4-45. See the 2016v1 rail specification sheet for additional information on rail projections.

Table 4-45. 2018 AEO growth rates for rail sub-groups

Sector	2016	2023	2026	2030
Rail Yards	1.0	0.9969	1.0410	1.0284
Class II/III Railroads	1.0	0.9969	1.0410	1.0284
Commuter/Passenger	1.0	1.0879	1.1310	1.2220

4.3.4 Sources Outside of the United States (onroad_can, onroad_mex, othpt, canada_ag, canada_og2D, ptfire_othna, othar, othafdust, othptdust)

This section discusses the projection of emissions from Canada and Mexico. Information about the base year inventory used for these projections or the naming conventions can be found in Section 2.7. Most of the Canada and Mexico projections are based on inventories and other data from the 2016v1 platform applied to the 2016v2 platform base year inventories.

For the 2016v1 platform, ECCC provided data from which Canadian analytic year projections could be derived in a file called "Projected_CAN2015_2023_2028.xlsx", which includes emissions data for 2015, 2023, and 2028 by pollutant, province, ECCC sub-class code, and other source categories. ECCC sub-class codes are present in most Canadian inventories and are similar to SCC, but more detailed for some types of sources and less detailed for other types of sources. For most Canadian inventories, 2023 and 2026 inventories were projected from the new 2016 base year inventory using projection factors based on the ECCC sub-class level data from the 2016v1 platform, except with the 2015-to-2023 trend reduced to a 2016-to-2023 trend (i.e., reduce the total change by 1/8), and with 2026 interpolated between 2023 and 2028. Exceptions to this general procedure are noted below. For example, ECCC sub-class level data could not be used to project inventories where the sub-class codes changed from 2016v1 to 2016v2. Fire emissions in Canada and Mexico in the ptfire_othna sector were not projected.

4.3.4.1 Canadian fugitive dust sources (othafdust, othptdust)

Canadian area source dust (othafdust)

For Canadian area source dust sources, ECCC sub-class level data from 2016v1 platform was used to project the 2016v2 base year inventory to 2023 and 2028. Emissions for 2026 were interpolated between the 2023 and 2028 emissions. As with the base year, the analytic year dust emissions are pre-adjusted, so analytic year othafdust follows the same emissions processing methodology as the base year with respect to the transportable fraction and meteorological adjustments.

Canadian point source dust (othptdust)

In 2016v1 platform, ECCC provided sub-class level emissions data for the othptdust sector for the base and analytic years. Since the othptdust projections in 2016v1 were nearly flat, we decided to not project othptdust for the 2016v2 or 2016v3 platforms (i.e., the 2016fj othptdust emissions were reused for all analytic year cases).

4.3.4.2 Point Sources in Canada and Mexico (othpt, canada_ag, canada_og2D)

Canada point agriculture and oil and gas emissions

For Canadian agriculture and upstream oil and gas sources, ECCC sub-class level data from 2016v1 platform was used to project the 2016v2 base year inventory to 2023 and 2028. Emissions for 2026 were interpolated between 2023 and 2028. This procedure was applied to the entire canada_ag and canada_og2D sectors, and to the oil and gas elevated point source inventory in the othpt sector. For the ag inventories, the sub-class codes are similar in detail to SCCs: fertilizer has a single sub-class code, and animal emissions categories (broilers, dairy, horses, sheep, etc) each have a separate sub-class code.

Airports and other Canada point sources

For the Canada airports inventory in the othpt sector, the ECCC sub-class codes changed from 2016v1 to 2016v2 platform. Therefore, the ECCC sub-class level data from 2016v1 platform could not be used to project the 2016v2 base year inventory. Instead, projection factors were based on total airport emissions from the 2016v1 Canada inventory by province and pollutant. As with other sectors, 2026 emissions were interpolated between 2023 and 2028.

In the 2016v1 platform, analytic year projections for stationary point sources (excluding ag) were provided by ECCC for 2023 and 2028 rather than calculated by way of ECCC sub-class code data. Additionally, projection information for many sub-class codes in the 2016v2 base year stationary point inventories was not available in the 2016v1 sub-class code data. Therefore, sub-class code data was not used to project stationary point sources, and instead, those sources were projected using factors based on total stationary (excluding ag and upstream oil and gas) point source emissions from the 2016v1 platform for 2015, 2023, and 2028, by province and pollutant. This is the same procedure that was used for airports, except using different projection factors based on only the stationary sources.

Mexico

The othpt sector includes a general point source inventory in Mexico which was updated for the 2016v2 platform. Similar to the procedure for projecting Canadian stationary point sources, factors for projecting from 2016 to 2023 and 2026 were calculated from the 2016v1 platform Mexico point source inventories by state and pollutant. Mexico point source emissions for 2026 were interpolated between 2023 and 2028.

4.3.4.3 Nonpoint sources in Canada and Mexico (othar)

Canadian stationary sources

In the 2016v1 platform, analytic year projections for stationary area sources in Canada were provided by ECCC for 2023 and 2028 rather than calculated by way of ECCC sub-class code data. Additionally, projection information for many sub-class codes in the 2016v2 base year stationary area source inventory was not available in the 2016v1 sub-class code data. Therefore, sub-class code data was not used to project stationary area sources, and instead, those sources were projected using factors based on total stationary area source emissions from the 2016v1 platform for 2015, 2023, and 2028, by province and pollutant. This is the same procedure that was used for airports and stationary point sources, except using different projection factors based on only the stationary area sources. Projection factors for 2026 were interpolated from the factors for 2023 and 2028.

For the 2016v1 platform, ECCC provided an additional stationary area source inventory for 2023 and 2028 representing electric power generation (EPG). According to ECCC, this inventory's emissions do not double count the 2023 and 2028 point source inventories, and it is appropriate to include this area source EPG inventory in the othar sector as an additional standalone inventory in the analytic years. Therefore, the 2016v1 area source EPG inventory was included in the 2016v2 platform analytic year cases. Emissions for 2026 were interpolated between 2023 and 2028.

Canadian mobile sources

Projection information for mobile nonroad sources, including rail and CMV, is covered by the ECCC sub-class level data for 2015, 2023, and 2028. ECCC sub-class level data from 2016v1 platform was used to project the 2016v2 base year inventory to 2023 and 2028. Emissions for 2026 were interpolated from 2023 and 2028. For the nonroad inventory, the sub-class code is analogous to the SCC7 level in U.S. inventories. For example, there are separate sub-class codes for fuels (e.g., 2-stroke gasoline, diesel, LPG) and nonroad equipment sector (e.g., construction, lawn and garden, logging, recreational marine) but not for individual vehicle types within each category (e.g., snowmobiles, tractors). For rail, the sub-class code is closer to full SCCs in the NEI.

Mexico

The othar sector includes two Mexico inventories, a stationary area source inventory and a nonroad inventory. Similar to point, factors for projecting the 2016v2 base year inventories to 2023 and 2028 were calculated from the 2016v1 platform Mexico area and nonroad inventories by state and pollutant. Separate projections were calculated for the area and nonroad inventories. Emissions for 2026 were interpolated between 2023 and 2028, including for nonroad (unlike in Canada).

4.3.4.4 Onroad sources in Canada and Mexico (onroad_can, onroad_mex)

For Canadian mobile onroad sources, projection information is covered by the ECCC sub-class level data for 2015, 2023, and 2028. ECCC sub-class level data from 2016v1 platform was used to project the 2016v2 base year inventory to 2023 and 2028. Emissions for 2026 were interpolated from 2023 and 2028. For the onroad inventory, the sub-class code is analogous to the SCC6+process level in U.S. inventories, in that it specifies fuel type, vehicle type, and process (e.g., brake, tire, exhaust, refueling), but not road type.

For Mexican mobile onroad sources, MOVES-Mexico was run to create emissions inventories for years 2023, 2028, and 2035. The emissions for 2023 were reused from the 2016v1 platform, and 2026 emissions were interpolated between 2023-2028.

5 Emission Summaries

Tables 5-1 through Table 5-3 summarize annual emissions by sector for the 2016gf, 2023gf, and 2026gf cases at the national level by sector for the contiguous U.S. and for the portions of Canada and Mexico inside the larger 12km domain (12US1) discussed in Section 3.1. Table 5-4 and Table 5-5 provide similar summaries for the 36-km domain (36US3) for 2016 and 2023. Note that totals for the 12US2 domain are not available here, but the sum of the U.S. sectors would be essentially the same and only the Canadian and Mexican emissions would change according to how far north and south the grids extend. Note that the afdust sector emissions here represent the emissions *after* application of both the land use (transport fraction) and meteorological adjustments; therefore, this sector is called "afdust_adj" in these summaries. The afdust emissions in the 36km domain are smaller than those in the 12km domain due to how the adjustment factors are computed and the size of the grid cells. The onroad sector totals are post-SMOKE-MOVES totals, representing air quality model-ready emission totals, and include CARB emissions for California. The cmv sectors include U.S. emissions within state waters only; these extend to roughly 3-5 miles offshore and include CMV emissions at U.S. ports. "Offshore" represents CMV emissions that are outside of U.S. state waters. The total of all US sectors is listed as "Con U.S. Total."

Table 5-6 and Table 5-7 summarize ozone season NOx and VOC emissions, respectively, for the 2016gf, 2023gf, and 2026gf cases.

State totals and other summaries are available in the reports area on the FTP site for the 2016v3 platform (https://gaftp.epa.gov/Air/emismod/2016/v3/reports).

Table 5-1. National by-sector CAP emissions for the 2016gf case, 12US1 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,314,612	880,002		
airports	479,736	0	123,838	9,952	8,675	14,827	53,420
cmv_c1c2	23,710	84	163,598	4,486	4,348	636	6,477
cmv_c3	14,267	40	112,701	2,246	2,066	4,609	8,822
fertilizer		1,436,969					
livestock		2,502,587					219,703
nonpt	1,921,889	102,840	739,465	567,555	470,789	166,391	827,897
nonroad	10,593,504	1,845	1,110,243	109,008	103,047	1,513	1,134,711
np_oilgas	762,177	20	585,683	13,236	13,145	40,748	2,532,881
np_solvents	36	58	34	469	448	5	2,606,495
onroad	18,313,321	107,791	3,546,597	233,680	113,716	25,969	1,317,694
pt_oilgas	195,308	375	374,037	13,132	12,736	42,815	238,673
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
ptegu	655,873	23,850	1,318,074	164,132	133,606	1,565,196	33,755
ptfire-rx	7,094,333	130,849	127,470	778,864	655,354	58,690	1,546,840
ptfire-wild	6,643,510	109,088	100,030	684,798	580,377	52,719	1,567,400
ptnonipm	1,381,321	64,168	913,795	390,628	250,076	636,685	765,281
rail	104,551	326	559,381	16,344	15,819	457	26,082
rwc	2,230,478	16,940	35,198	309,854	308,965	8,247	334,158
beis	3,390,977		1,001,873				31,014,251
Con. U.S. Total + beis	**54,067,638**	**4,549,105**	**10,822,258**	**9,651,686**	**3,580,122**	**2,623,203**	**44,251,723**
Can./Mex./Offshore							
Sector	**CO**	**NH3**	**NOX**	**PM10**	**PM2_5**	**SO2**	**VOC**
Canada ag		491,788					104,968
Canada oil and gas 2D	667	7	3,241	186	186	3,944	510,623
Canada othafdust				696,793	108,328		
Canada othar	2,191,451	3,819	323,152	225,620	177,134	16,294	740,566
Canada onroad_can	1,849,517	7,685	407,423	26,017	14,012	1,739	158,429
Canada othpt	1,116,192	19,482	651,451	90,042	43,051	990,049	148,216
Canada othptdust				152,566	53,684		
Canada ptfire_othna	761,402	13,032	16,359	84,481	71,749	6,731	185,476
Canada CMV	10,587	36	92,110	1,641	1,525	2,807	5,122
Mexico othar	115,887	112,005	60,196	105,146	34,788	1,733	362,643
Mexico onroad_mex	1,828,101	2,789	442,410	15,151	10,836	6,247	158,812
Mexico othpt	109,015	1,096	190,997	54,044	37,491	355,883	35,768
Mexico ptfire_othna	383,162	7,436	16,604	44,994	38,178	2,785	131,499
Mexico CMV	0	0	0	0	0	0	0
Offshore cmv in Federal waters	32,745	126	289,633	7,051	6,530	27,482	15,956
Offshore cmv outside Federal waters	23,579	444	259,993	25,074	23,074	183,595	11,207
Offshore pt_oilgas	51,872	8	49,962	636	635	462	38,833
Non-U.S. Total	**8,474,180**	**659,754**	**2,803,533**	**1,529,440**	**621,202**	**1,599,752**	**2,608,117**

Table 5-2. National by-sector CAP emissions for the 2023gf case, 12US1 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,378,445	893,940		
airports	497,816	0	135,028	9,990	8,731	16,261	55,592
cmv_c1c2	23,741	60	117,171	3,212	3,113	243	4,559
cmv_c3	17,448	49	109,834	2,753	2,533	5,634	10,876
fertilizer		1,436,969					
livestock		2,593,384					226,860
nonpt	1,920,941	103,603	725,280	560,108	474,271	121,178	789,771
nonroad	10,890,827	2,114	742,436	71,039	66,532	1,057	891,025
np_oilgas	832,845	22	605,993	14,702	14,603	87,319	2,675,843
np_solvents	37	61	36	499	476	6	2,702,053
onroad	12,803,175	97,304	1,646,377	188,180	62,338	11,172	806,689
pt_oilgas	214,732	357	393,667	17,484	16,766	72,802	217,443
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
ptegu	542,096	25,741	888,700	121,657	102,620	1,195,002	39,915
ptfire-rx	7,094,333	130,849	127,470	778,864	655,354	58,690	1,546,840
ptfire-wild	6,643,510	109,088	100,030	684,798	580,377	52,719	1,567,400
ptnonipm	1,355,805	67,871	836,547	371,162	235,390	495,093	755,872
rail	105,631	331	476,559	13,104	12,677	375	20,807
rwc	2,207,014	16,738	36,856	302,922	302,016	7,704	330,504
beis	3,390,977		1,001,873				31,014,251
Con. U.S. Total + beis	**48,803,574**	**4,635,816**	**7,954,098**	**9,557,608**	**3,458,688**	**2,128,948**	**43,673,481**
Can./Mex./Offshore							
Sector	**CO**	**NH3**	**NOX**	**PM10**	**PM2_5**	**SO2**	**VOC**
Canada ag		583,282					104,584
Canada oil and gas 2D	477	7	1,920	128	128	3,305	412,111
Canada othafdust				782,334	121,430		
Canada othar	2,196,835	3,729	267,788	219,440	164,701	16,198	740,364
Canada onroad_can	1,590,905	6,850	254,786	26,537	11,305	937	102,118
Canada othpt	1,129,621	22,315	553,839	72,613	42,672	877,388	154,137
Canada othptdust				152,566	53,684		
Canada ptfire_othna	761,402	13,032	16,359	84,481	71,749	6,731	185,476
Canada CMV	11,436	39	66,994	1,776	1,650	2,979	5,461
Mexico other	126,192	109,995	69,552	107,496	36,249	1,953	404,664
Mexico onroad_mex	1,772,026	3,266	427,900	17,023	11,764	7,556	161,115
Mexico othpt	123,814	1,321	187,731	59,146	40,987	292,546	44,668
Mexico ptfire_othna	383,162	7,436	16,604	44,994	38,178	2,785	131,499
Mexico CMV	0	0	0	0	0	0	0
Offshore cmv in Federal waters	39,301	148	254,448	8,306	7,673	34,226	19,059
Offshore cmv outside Federal waters	28,839	280	317,415	15,797	14,538	41,868	13,690
Offshore pt_oilgas	51,872	8	49,962	636	635	462	38,833
Non-U.S. Total	**8,215,884**	**751,708**	**2,485,299**	**1,593,275**	**617,343**	**1,288,934**	**2,517,779**

Table 5-3. National by-sector CAP emissions for the 2026gf case, 12US1 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,403,935	899,647		
airports	535,239	0	151,407	10,302	9,024	18,330	59,611
cmv_c1c2	23,990	52	102,154	2,807	2,720	244	3,919
cmv_c3	19,005	53	110,076	3,000	2,760	6,128	11,890
fertilizer		1,436,969					
livestock		2,629,312					230,160
nonpt	1,930,169	103,868	723,871	568,094	481,072	122,437	762,403
nonroad	11,081,612	2,159	657,502	62,218	58,045	1,075	850,020
np_oilgas	830,088	22	597,874	14,822	14,723	89,777	2,610,993
np_solvents	38	64	38	519	496	6	2,781,475
onroad	11,298,677	97,669	1,303,964	187,332	56,017	13,689	680,034
pt_oilgas	211,373	334	385,071	17,371	16,650	73,983	213,838
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
ptegu	410,878	25,514	663,681	96,276	83,619	855,909	35,019
ptfire-rx	7,094,333	130,849	127,470	778,864	655,354	58,690	1,546,840
ptfire-wild	6,643,510	109,088	100,030	684,798	580,377	52,719	1,567,400
ptnonipm	1,376,876	68,146	848,119	374,437	237,646	496,819	757,055
rail	108,234	339	453,446	12,052	11,657	384	19,167
rwc	2,196,869	16,667	37,258	300,475	299,564	7,522	329,113
beis	3,390,977		1,001,873				31,014,251
Con. U.S. Total + beis	**47,414,514**	**4,672,382**	**7,274,075**	**9,555,990**	**3,436,322**	**1,801,407**	**43,490,369**
Can./Mex./Offshore							
Sector	**CO**	**NH3**	**NOX**	**PM10**	**PM2_5**	**SO2**	**VOC**
Canada ag		632,182					104,570
Canada oil and gas 2D	497	7	1,493	133	133	3,550	447,884
Canada othafdust				825,908	128,106		
Canada other	2,206,851	3,717	254,419	218,350	161,430	16,174	755,871
Canada onroad_can	1,504,701	6,461	210,090	26,684	10,386	893	82,677
Canada othpt	1,154,185	23,274	495,903	75,829	44,714	872,534	159,956
Canada othptdust				152,566	53,684		
Canada ptfire_othna	761,402	13,032	16,359	84,481	71,749	6,731	185,476
Canada CMV	11,823	40	70,103	1,837	1,706	3,094	5,644
Mexico other	130,146	110,429	73,150	108,612	36,855	2,038	423,290
Mexico onroad_mex	1,677,896	3,546	407,181	18,048	12,307	8,141	163,311
Mexico othpt	131,373	1,445	200,959	63,917	44,176	301,303	48,989
Mexico ptfire_othna	383,162	7,436	16,604	44,994	38,178	2,785	131,499
Mexico CMV	0	0	0	0	0	0	0
Offshore cmv in Federal waters	42,791	160	244,576	9,007	8,313	37,795	20,739
Offshore cmv outside Federal waters	31,565	306	347,299	17,303	15,923	45,919	14,981
Offshore pt_oilgas	51,872	8	49,962	636	635	462	38,833
Non-U.S. Total	**8,088,265**	**802,045**	**2,388,098**	**1,648,303**	**628,296**	**1,301,417**	**2,583,718**

Table 5-4. National by-sector CAP emissions for the 2016gf case, 36US3 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,318,693	880,413		
airports	480,474	0	123,989	9,977	8,699	14,850	53,513
cmv_c1c2	23,713	84	163,617	4,487	4,349	636	6,478
cmv_c3	14,477	40	114,661	2,275	2,093	4,678	8,932
fertilizer		1,436,969					
livestock		2,502,588					219,703
nonpt	1,922,341	102,861	740,522	567,613	470,839	166,402	828,180
nonroad	10,598,518	1,845	1,110,424	109,045	103,082	1,514	1,135,706
np_oilgas	762,177	20	585,683	13,236	13,145	40,748	2,532,881
np_solvents	36	58	34	469	448	5	2,606,991
onroad	18,313,321	107,791	3,546,597	233,680	113,716	25,969	1,317,694
pt_oilgas	195,308	375	374,037	13,132	12,736	42,815	238,673
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
ptegu	655,909	23,850	1,318,272	164,137	133,610	1,565,196	33,760
ptfire-rx	7,094,333	130,849	127,470	778,864	655,354	58,690	1,546,840
ptfire-wild	6,643,510	109,088	100,030	684,798	580,377	52,719	1,567,400
ptnonipm	1,381,324	64,168	913,821	390,669	250,087	636,685	765,282
rail	104,551	326	559,381	16,344	15,819	457	26,082
rwc	2,255,551	16,969	35,687	314,299	313,410	8,324	334,761
beis	3,545,278		1,011,401				32,014,201
36US3 U.S. Total + beis	**54,253,467**	**4,549,158**	**10,835,865**	**9,660,408**	**3,585,127**	**2,623,383**	**45,254,258**
Can./Mex./Offshore							
Sector	**CO**	**NH3**	**NOX**	**PM10**	**PM2_5**	**SO2**	**VOC**
Canada ag		507,030					107,661
Canada oil and gas 2D	732	7	3,548	203	203	4,432	606,218
Canada othafdust				722,629	112,358		
Canada othar	2,352,757	4,115	358,976	239,649	188,729	17,031	779,607
Canada onroad_can	1,926,698	7,980	428,161	27,152	14,692	1,802	164,479
Canada othpt	1,379,994	21,394	832,840	102,218	50,224	1,124,153	203,402
Canada othptdust				152,834	52,953		
Canada ptfire_othna	6,282,821	104,683	134,301	685,169	580,963	60,914	1,501,988
Canada CMV	13,086	45	115,294	2,098	1,946	4,279	6,439
Mexico othar	1,699,433	562,057	235,176	465,425	252,429	12,630	1,588,164
Mexico onroad_mex	6,273,194	10,319	1,497,028	74,169	56,782	26,400	552,952
Mexico othpt	319,500	3,314	485,613	213,413	141,638	1,453,380	111,716
Mexico ptfire_othna	7,133,496	120,584	346,990	1,155,563	745,860	45,208	2,259,747
Mexico CMV	64,730	0	204,997	16,286	15,087	109,778	8,817
Offshore cmv in Federal waters	34,594	153	309,815	8,614	7,969	38,843	16,798
Offshore cmv outside Federal waters	89,532	1,199	1,019,219	93,844	86,363	693,479	40,839
Offshore pt_oilgas	51,872	8	49,962	636	635	462	38,833
Annual Total	**27,622,440**	**1,342,889**	**6,021,918**	**3,959,903**	**2,308,831**	**3,592,792**	**7,987,661**

Table 5-5. National by-sector CAP emissions for the 2023gf case, 36US3 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,382,529	894,351		
airports	498,620	0	135,173	10,015	8,754	16,284	55,689
cmv_c1c2	23,744	60	117,185	3,213	3,114	243	4,560
cmv_c3	17,704	49	111,755	2,789	2,566	5,718	11,011
fertilizer		1,436,969					
livestock		2,593,386					226,860
nonpt	1,921,427	103,626	726,404	560,167	474,321	121,189	790,046
nonroad	10,895,359	2,114	742,572	71,065	66,556	1,057	891,713
np_oilgas	832,845	22	605,993	14,702	14,603	87,319	2,675,843
np_solvents	37	61	36	499	476	6	2,702,549
onroad	12,807,931	97,317	1,646,798	188,227	62,355	11,173	807,048
pt_oilgas	214,732	357	393,667	17,484	16,766	72,802	217,443
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
ptegu	542,096	25,741	888,700	121,657	102,620	1,195,002	39,915
ptfire-rx	7,094,333	130,849	127,470	778,864	655,354	58,690	1,546,840
ptfire-wild	6,643,510	109,088	100,030	684,798	580,377	52,719	1,567,400
ptnonipm	1,355,811	67,871	836,598	371,204	235,401	495,093	755,874
rail	105,631	331	476,559	13,104	12,677	375	20,807
rwc	2,229,572	16,766	37,295	306,858	305,951	7,773	331,081
beis	3,545,278		1,011,401				32,014,201
36US3 U.S. Total + beis	**48,991,277**	**4,635,884**	**7,967,876**	**9,565,863**	**3,463,193**	**2,129,137**	**44,676,061**
Can./Mex./Offshore							
Sector	**CO**	**NH3**	**NOX**	**PM10**	**PM2_5**	**SO2**	**VOC**
Canada ag		600,883					107,266
Canada oil and gas 2D	527	7	2,115	142	142	3,714	489,811
Canada othafdust				810,859	125,871		
Canada othar	2,356,241	4,019	308,601	232,951	175,488	17,180	780,201
Canada onroad_can	1,655,613	7,109	268,025	27,680	11,859	971	106,159
Canada othpt	1,364,416	24,576	686,691	80,094	48,582	993,177	214,520
Canada othptdust				152,834	52,953		
Canada ptfire_othna	6,282,821	104,683	134,301	685,169	580,963	60,914	1,501,988
Canada CMV	14,048	49	83,837	2,264	2,099	4,599	6,821
Mexico other	1,821,647	552,207	263,072	483,534	266,265	13,459	1,731,394
Mexico onroad_mex	6,053,503	12,083	1,447,199	94,407	72,468	31,838	560,284
Mexico othpt	381,638	4,088	537,165	251,989	167,147	1,416,350	141,037
Mexico ptfire_othna	7,133,496	120,584	346,990	1,155,563	745,860	45,208	2,259,747
Mexico CMV	79,677	0	252,331	20,046	18,571	19,304	10,853
Offshore cmv in Federal waters	41,533	181	271,245	10,194	9,410	47,974	20,074
Offshore cmv outside Federal waters	109,733	756	1,249,272	59,007	54,301	157,866	50,170
Offshore pt_oilgas	51,872	8	49,962	636	635	462	38,833
Non-U.S. Total	**27,346,764**	**1,431,234**	**5,900,805**	**4,067,368**	**2,332,614**	**2,813,016**	**8,019,159**

Table 5-6. National by-sector Ozone Season NOx emissions summaries 12US1 grid (tons/o.s.)

Sector	2016gf	2023gf	2026gf
airports	55,023	59,995	67,273
cmv_c1c2_12	90,952	64,979	56,539
cmv_c3_12	265,891	279,095	289,473
nonpt	222,645	216,582	216,691
nonroad	566,188	380,010	335,761
np_oilgas	243,554	251,456	248,158
np_solvents	14	15	16
onroad	1,425,690	658,513	512,550
onroad_ca_adj	102,061	45,954	41,631
pt_oilgas	177,844	186,161	182,555
ptagfire	3,193	3,193	3,193
ptegu	604,426	372,414	289,044
ptnonipm	383,072	350,480	355,312
rail	236,771	201,707	191,917
rwc	4,279	4,527	4,595
Total U.S. Anthro	**4,381,606**	**3,075,082**	**2,794,707**
beis	599,643	599,643	599,643
ptfire-rx	20,531	20,531	20,531
ptfire-wild	55,500	55,500	55,500
Grand Total	**5,057,280**	**3,750,756**	**3,470,382**

Table 5-7. National by-sector Ozone Season VOC emissions summaries 12US1 grid (tons/o.s.)

Sector	2016gf	2023gf	2026gf
airports	23,735	24,700	26,486
cmv_c1c2_12	3,550	2,487	2,132
cmv_c3_12	14,613	18,040	19,796
livestock	152,495	157,531	159,757
nonpt	346,753	330,090	318,876
nonroad	573,637	435,998	411,793
np_oilgas	1,039,662	1,092,687	1,065,914
np_solvents	1,095,342	1,135,471	1,168,836
onroad	556,510	339,025	281,483
onroad_ca_adj	44,562	25,378	22,281
pt_oilgas	116,259	107,378	105,868
ptagfire	6,314	6,314	6,314
ptegu	16,220	17,993	16,199
ptnonipm	320,043	316,084	316,575
rail	11,039	8,806	8,112
rwc	36,547	37,975	38,354
Total U.S. Anthro	**4,357,282**	**4,055,957**	**3,968,775**
beis	24,776,664	24,776,664	24,776,664
ptfire-rx	277,019	277,019	277,019
ptfire-wild	1,005,261	1,005,261	1,005,261
Grand Total	**30,416,226**	**30,114,902**	**30,027,720**

6 References

Adelman, Z. 2012. *Memorandum: Fugitive Dust Modeling for the 2008 Emissions Modeling Platform*. UNC Institute for the Environment, Chapel Hill, NC. September 28, 2012.

Adelman, Z. 2016. *2014 Emissions Modeling Platform Spatial Surrogate Documentation*. UNC Institute for the Environment, Chapel Hill, NC. October 1, 2016. Available at https://gaftp.epa.gov/Air/emismod/2014/v1/spatial_surrogates/ .

Adelman, Z., M. Omary, Q. He, J. Zhao and D. Yang, J. Boylan, 2012. "A Detailed Approach for Improving Continuous Emissions Monitoring Data for Regulatory Air Quality Modeling." Presented at the 2012 International Emission Inventory Conference, Tampa, Florida. Available from http://www.epa.gov/ttn/chief/conference/ei20/index.html#ses-5.

Appel, K.W., Napelenok, S., Hogrefe, C., Pouliot, G., Foley, K.M., Roselle, S.J., Pleim, J.E., Bash, J., Pye, H.O.T., Heath, N., Murphy, B., Mathur, R., 2018. Overview and evaluation of the Community Multiscale Air Quality Model (CMAQ) modeling system version 5.2. In Mensink C., Kallos G. (eds), Air Pollution Modeling and its Application XXV. ITM 2016. Springer Proceedings in Complexity. Springer, Cham. Available at https://doi.org/10.1007/978-3-319-57645-9_11.

Bash, J.O., Baker, K.R., Beaver, M.R., Park, J.-H., Goldstein, A.H., 2016. Evaluation of improved land use and canopy representation in BEIS with biogenic VOC measurements in California. Available from http://www.geosci-model-dev.net/9/2191/2016/.

BEA, 2012. "2013 Global Outlook projections prepared by the Conference Board in November 2012". U.S. Bureau of Economic Analysis. Available from: http://www.conference-board.org/data/globaloutlook.cfm.

Bullock Jr., R, and K. A. Brehme (2002) "Atmospheric mercury simulation using the CMAQ model: formulation description and analysis of wet deposition results." Atmospheric Environment 36, pp 2135–2146. Available at https://doi.org/10.1016/S1352-2310(02)00220-0.

California Air Resources Board (CARB): ORGPROF - Organic chemical profiles for source categories, 2018. https://ww2.arb.ca.gov/speciation-profiles-used-carb-modeling .

California Air Resources Board (CARB): 2005 Architectural Coatings Survey – Final Report, 2007.

California Air Resources Board (CARB): 2010 Aerosol Coatings Survey Results, 2012.

California Air Resources Board (CARB): 2014 Architectural Coatings Survey - Draft Data Summary, 2014.

California Air Resources Board (CARB): Final 2015 Consumer & Commercial Product Survey Data Summaries, 2019.

Coordinating Research Council (CRC). Report A-100. Improvement of Default Inputs for MOVES and SMOKE-MOVES. Final Report. February 2017. Available at http://crcsite.wpengine.com/wp-content/uploads/2019/05/ERG_FinalReport_CRCA100_28Feb2017.pdf.

Coordinating Research Council (CRC). Report A-115. Developing Improved Vehicle Population Inputs for the 2017 National Emissions Inventory. Final Report. April 2019. Available at http://crcsite.wpengine.com/wp-content/uploads/2019/05/CRC-Project-A-115-Final-Report_20190411.pdf .

Drillinginfo, Inc. 2015. "DI Desktop Database powered by HPDI." Currently available from https://www.enverus.com/.

England, G., Watson, J., Chow, J., Zielenska, B., Chang, M., Loos, K., Hidy, G., 2007. "Dilution-Based Emissions Sampling from Stationary Sources: Part 2-- Gas-Fired Combustors Compared with Other Fuel-Fired Systems," Journal of the Air & Waste Management Association, 57:1, 65-78, DOI: 10.1080/10473289.2007.10465291. Available at https://www.tandfonline.com/doi/abs/10.1080/10473289.2007.10465291.

EPA, 2017. Light-Duty Vehicle, Light-Duty Truck, and Medium-Duty Passenger Vehicle Tier 2 Exhaust Emission Standards. Office of Transportation and Air Quality, Ann Arbor, MI 48105. Available at: https://www.epa.gov/emission-standards-reference-guide/epa-emission-standards-light-duty-vehicles-and-trucks-and.

EPA, 2008. Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder. EPA420-R-08-001. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P10023S4.PDF?Dockey=P10023S4.PDF .

EPA, 2012d. Preparation of Emission Inventories for the Version 5.0, 2007 Emissions Modeling Platform Technical Support Document. Available from: https://www.epa.gov/air-emissions-modeling/2007-version-50-technical-support-document .

EPA, 2013rwc. "2011 Residential Wood Combustion Tool version 1.1, September 2013", available from US EPA, OAQPS, EIAG.

EPA, 2015b. Draft Report Speciation Profiles and Toxic Emission Factors for Nonroad Engines. EPA-420-R-14-028. Available at https://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=309339&CFID=83476290&CFTOKEN=35281617.

EPA, 2015c. Speciation of Total Organic Gas and Particulate Matter Emissions from On-road Vehicles in MOVES2014. EPA-420-R-15-022. Available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NOJG.pdf.

EPA, 2016. SPECIATE Version 4.5 Database Development Documentation, U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Research Triangle Park, NC 27711, EPA/600/R-16/294, September 2016. Available at https://www.epa.gov/sites/production/files/2016-09/documents/speciate_4.5.pdf.

EPA, 2017. Additional Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2023 technical support document. Available at: https://www.epa.gov/sites/production/files/2017-11/documents/2011v6.3_2023en_update_emismod_tsd_oct2017.pdf.

EPA, 2018. AERMOD Model Formulation and Evaluation Document. EPA-454/R-18-003. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711. Available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100UT95.PDF .

EPA, 2018. 2014 National Emission Inventory, version 2 Technical Support Document. U.S. Environmental Protection Agency, OAQPS, Research Triangle Park, NC 27711. Available at: https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-technical-support-document-tsd.

EPA, 2019. Final Report, SPECIATE Version 5.0, Database Development Documentation, Research Triangle Park, NC, EPA/600/R-19/988. Available at https://www.epa.gov/air-emissions-modeling/speciate-51-and-50-addendum-and-final-report .

EPA, 2020. Population and Activity of Onroad Vehicles in MOVES3. EPA-420-R-20-023. Office of Transportation and Air Quality. US Environmental Protection Agency. Ann Arbor, MI. November 2020. Available under the MOVES3 section at https://www.epa.gov/moves/moves-technical-reports

EPA, 2021. Technical Support Document (TSD) Preparation of Emissions Inventories for the 2016v2 North American Emissions Modeling Platform. Available at https://www.epa.gov/air-emissions-modeling/2016v2-platform.

EPA, 2021b. 2017 National Emission Inventory: January 2021 Updated Release, Technical Support Document. U.S. Environmental Protection Agency, OAQPS, Research Triangle Park, NC 27711. Available at: https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-technical-support-document-tsd.

EPA, 2021c. Technical Support Document (TSD) Preparation of Emissions Inventories for the 2016v1 North American Emissions Modeling Platform. Available at https://www.epa.gov/air-emissions-modeling/2016-version-1-technical-support-document.

EPA, 2021d. 2017 National Emissions Inventory (NEI), Research Triangle Park, NC, January 2021. https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data.

EPA, 2022. 2019 National Emissions Inventory (NEI) Technical Support Document: Point Data Category, Research Triangle Park, NC. EPA-454/R-22-001. Available at: https://www.epa.gov/air-emissions-modeling/2019-nei-technical-support-documentation.

ERG, 2014a. Develop Mexico Future Year Emissions Final Report. Available at https://gaftp.epa.gov/air/emismod/2011/v2platform/2011emissions/Mexico_Emissions_WA%204-09_final_report_121814.pdf .

ERG, 2016b. "Technical Memorandum: Modeling Allocation Factors for the 2014 Oil and Gas Nonpoint Tool." Available at https://gaftp.epa.gov/air/emismod/2014/v1/spatial_surrogates/oil_and_gas/ .

ERG, 2017. "Technical Report: Development of Mexico Emission Inventories for the 2014 Modeling Platform." Available at https://gaftp.epa.gov/Air/emismod/2014/v2/2014fd/emissions/EPA%205-18%20Report_Clean%20Final_01042017.pdf .

ERG, 2018. Technical Report: "2016 Nonpoint Oil and Gas Emission Estimation Tool Version 1.0". Available at https://gaftp.epa.gov/air/emismod/2016/v1/reports/2016%20Nonpoint%20Oil%20and%20Gas%20Emission%20Estimation%20Tool%20V1_0%20December_2018.pdf.

ERG, 2019a. "2017 Nonpoint Oil and Gas Emission Estimation Tool Revisions" Available from: https://gaftp.epa.gov/air/nei/2017/doc/supporting_data/nonpoint/2017%20Oil%20and%20Gas%20Memos.zip.

ERG, 2019b. Category 1 and 2 Commercial Marine Emissions Inventory. Available from: https://www.epa.gov/sites/default/files/2019-11/cmv_methodology_documentation.zip.

ERG, 2019c. 2016 versus 2017 entrance and clearance data. Available from:https://gaftp.epa.gov/Air/emismod/2016/v2/reports/cmv/EandC_2016_to_2017_Activity_Ratios.pdf .

The Freedonia Group, 2016. Solvents, Industry Study #3429.

Frost & Sullivan, 2010. "Project: Market Research and Report on North American Residential Wood Heaters, Fireplaces, and Hearth Heating Products Market (P.O. # PO1-IMP403-F&S). Final Report April 26, 2010", pp. 31-32. Prepared by Frost & Sullivan, Mountain View, CA 94041.

Gkatzelis, G.I., Coggon, M.M., McDonald, B.C., Peischl, J., Aikin, K.C., Gilman, J.B., Trainer, M., Warneke, C. Identifying Volatile Chemical Product Tracer Compounds in US Cities. Environ. Sci. Technol. 2021, 55 (1), 188−199.

Houck, 2011. "Dirty- vs. Clean-Burning? What percent of freestanding wood heaters in use in the U.S. today are still old, uncertified units?" Hearth and Home, December 2011.

Hutchins, M.L., Holkzworth, R.H., Brundell, J.B., and Rodger, C.J., 2012. Relative detection efficiency of the World Wide Lightning Location Network. Available from http://wwlln.net/publications/Hutchins_Detection_Efficiency_RadioSci_2012.pdf.

Kang et al., 2022. Assessing the Impact of Lightning NOx Emissions in CMAQ using Lightning Flash Data from WWLLN over the Contiguous United States. Available from https://doi.org/10.3390/atmos13081248.

Khare, P., and Gentner, D. R., 2018. Considering the future of anthropogenic gas-phase organic compound emissions and the increasing influence of non-combustion sources on urban air quality, Atmos Chem Phys, 18, 5391-5413, 10.5194/acp-18-5391-2018.

Luecken D., Yarwood G, Hutzell WT, 2019. Multipollutant modeling of ozone, reactive nitrogen and HAPs across the continental US with CMAQ-CB6. Atmospheric environment. 2019 Mar 15;201:62-72.

Mansouri, K., Grulke, C. M., Judson, R. S., and Williams, A. J., 2018. OPERA models for predicting physicochemical properties and environmental fate endpoints, J Cheminformatics, 10, 10.1186/s13321-018-0263-1.

McCarty, J.L., Korontzi, S., Jutice, C.O., and T. Loboda. 2009. The spatial and temporal distribution of crop residue burning in the contiguous United States. Science of the Total Environment, 407 (21): 5701-5712. Available at https://www.sciencedirect.com/science/article/abs/pii/S1352231008000137?via%3Dihub .

MDNR, 2008. "A Minnesota 2008 Residential Fuelwood Assessment Survey of individual household responses". Minnesota Department of Natural Resources. Available from http://files.dnr.state.mn.us/forestry/um/residentialfuelwoodassessment07_08.pdf.

NCAR, 2016. FIRE EMISSION FACTORS AND EMISSION INVENTORIES, FINN Data. downloaded 2014 SAPRC99 version from https://www.acom.ucar.edu/Data/fire/ .

NESCAUM, 2006. "Assessment of Outdoor Wood-fired Boilers". Northeast States for Coordinated Air Use Management (NESCAUM) report. Available from http://www.nescaum.org/documents/assessment-of-outdoor-wood-fired-boilers/2006-1031-owb-report_revised-june2006-appendix.pdf.

NYSERDA, 2012. "Environmental, Energy Market, and Health Characterization of Wood-Fired Hydronic Heater Technologies, Final Report". New York State Energy Research and Development Authority (NYSERDA). Available from: https://www-nyserda-ny-gov.webpkgcache.com/doc/-/s/www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Research/Environmental/Wood-Fired-Hydronic-Heater-Tech-Summary.pdf .

Pechan, 2001. E.H. Pechan & Associates, Inc., Control Measure Development Support—Analysis of Ozone Transport Commission Model Rules, Springfield, VA, prepared for the Ozone Transport Commission, Washington, DC, March 31, 2001. Available at https://otcair.org/upload/Documents/Reports/Control%20Measure%20Development%20Support.pdf.

Pouliot, G., H. Simon, P. Bhave, D. Tong, D. Mobley, T. Pace, and T. Pierce. 2010. "Assessing the Anthropogenic Fugitive Dust Emission Inventory and Temporal Allocation Using an Updated Speciation of Particulate Matter." International Emission Inventory Conference, San Antonio, TX. Available at http://www3.epa.gov/ttn/chief/conference/ei19/session9/pouliot_pres.pdf.

Pouliot, G. and J. Bash, 2015. Updates to Version 3.61 of the Biogenic Emission Inventory System (BEIS). Presented at Air and Waste Management Association conference, Raleigh, NC, 2015.

Pouliot G, Rao V, McCarty JL, Soja A. Development of the crop residue and rangeland burning in the 2014 National Emissions Inventory using information from multiple sources. Journal of the Air & Waste Management Association. 2017 Apr 27;67(5):613-22.

Pye, H. O. T.; Pouliot, G. A., 2012. Modeling the role of alkanes, polycyclic aromatic hydrocarbons, and their oligomers in secondary organic aerosol formation. Environ. Sci. Technol. 2012, 46, 6041−6047.

Raffuse, S., D. Sullivan, L. Chinkin, S. Larkin, R. Solomon, A. Soja, 2007. Integration of Satellite-Detected and Incident Command Reported Wildfire Information into BlueSky, June 27, 2007. Available at: http://getbluesky.org/smartfire/docs.cfm.

Ramboll (Shah, T., Yarwood G.,) and EPA (Eyth, A., Strum, M), 2017. COMPOSITION OF ORGANIC GAS EMISSIONS FROM FLARING NATURAL GAS, Presented at the 2017 International Emission Inventory Conference, August 18, 2017. Available at https://www.epa.gov/sites/production/files/2017-11/documents/organic_gas.pdf. Additional Memo from Ramboll Environ to EPA (same title as presentation) dated September 23, 2016.

Ramboll, 2020. https://github.com/CMASCenter/Speciation-Tool/blob/master/docs/Ramboll_sptool_mapping_updates_AE7_AE8_24Mar2020_final_full.pdf.

Reichle, L., R. Cook, C. Yanca, D. Sonntag, 2015. "Development of organic gas exhaust speciation profiles for nonroad spark-ignition and compression-ignition engines and equipment", Journal of the Air & Waste Management Association, 65:10, 1185-1193, DOI: 10.1080/10962247.2015.1020118. Available at https://doi.org/10.1080/10962247.2015.1020118.

Reff, A., Bhave, P., Simon, H., Pace, T., Pouliot, G., Mobley, J., Houyoux. M. "Emissions Inventory of PM2.5 Trace Elements across the United States", Environmental Science & Technology 2009 43 (15), 5790-5796, DOI: 10.1021/es802930x. Available at https://doi.org/10.1021/es802930x.

Sarwar, G., S. Roselle, R. Mathur, W. Appel, R. Dennis, "A Comparison of CMAQ HONO predictions with observations from the Northeast Oxidant and Particle Study", Atmospheric Environment 42 (2008) 5760–5770). Available at https://doi.org/10.1016/j.atmosenv.2007.12.065.

Schauer, J., G. Lough, M. Shafer, W. Christensen, M. Arndt, J. DeMinter, J. Park, "Characterization of Metals Emitted from Motor Vehicles," Health Effects Institute, Research Report 133, March 2006. Available at https://www.healtheffects.org/publication/characterization-metals-emitted-motor-vehicles.

Seltzer, K. M., Pennington, E., Rao, V., Murphy, B. N., Strum, M., Isaacs, K. K., and Pye, H. O. T., 2021. Reactive organic carbon emissions from volatile chemical products, Atmos. Chem. Phys., 21, 5079–5100, https://doi.org/10.5194/acp-21-5079-2021.

Skamarock, W., J. Klemp, J. Dudhia, D. Gill, D. Barker, M. Duda, X. Huang, W. Wang, J. Powers, 2008. A Description of the Advanced Research WRF Version 3. NCAR Technical Note. National Center for Atmospheric Research, Mesoscale and Microscale Meteorology Division, Boulder, CO. June 2008. Available at: https://opensky.ucar.edu/islandora/object/technotes:500 .

Sullivan D.C., Raffuse S.M., Pryden D.A., Craig K.J., Reid S.B., Wheeler N.J.M., Chinkin L.R., Larkin N.K., Solomon R., and Strand T. (2008) Development and applications of systems for modeling emissions and smoke from fires: the BlueSky smoke modeling framework and SMARTFIRE: 17th International Emissions Inventory Conference, Portland, OR, June 2-5.

Swedish Environmental Protection Agency, 2004. Swedish Methodology for Environmental Data; Methodology for Calculating Emissions from Ships: 1. Update of Emission Factors.

U.S. Census Bureau, Economy Wide Statistics Division, 2018. County Business Patterns, 2018. https://www.census.gov/programs-surveys/cbp/data/datasets.html .

U.S. Bureau of Labor Statistics, 2020. Producer Price Index by Industry, retrieved from FRED, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/categories/31 .

U.S. Census Bureau, 2011 Paint and Allied Products - 2010, MA325F(10). https://www.census.gov/data/tables/time-series/econ/cir/ma325f.html .

U.S. Census Bureau, 2021. 2018 Annual Survey of Manufacturers (ASM), Washington D.C., USA. https://www.census.gov/data/developers/data-sets/Annual-Survey-of-Manufactures.html .

U.S. Department of Transportation and the U.S. Department of Commerce, 2015. 2012 Commodity Flow Survey, EC12TCF-US. https://www.census.gov/library/publications/2015/econ/ec12tcf-us.html .

U.S. Energy Information Administration, 2019. The Distribution of U.S. Oil and Natural Gas Wells by Production Rate, Washington, DC. https://www.eia.gov/petroleum/wells/

Wang, Y., P. Hopke, O. V. Rattigan, X. Xia, D. C. Chalupa, M. J. Utell. (2011) "Characterization of Residential Wood Combustion Particles Using the Two-Wavelength Aethalometer", Environ. Sci. Technol., 45 (17), pp 7387–7393. Available at https://doi.org/10.1021/es2013984.

Weschler, C. J., and Nazaroff, W. W., 2008. Semivolatile organic compounds in indoor environments, Atmos Environ, 42, 9018-9040.

Wiedinmyer, C., 2001. NCAR BVOC Enclosure Database. National Center for Atmospheric Research, Boulder, CO

Wiedinmyer, C., S.K. Akagi, R.J. Yokelson, L.K. Emmons, J.A. Al-Saadi[3], J. J. Orlando[1], and A. J. Soja. (2011) "The Fire INventory from NCAR (FINN): a high resolution global model to estimate the emissions from open burning", Geosci. Model Dev., 4, 625-641. http://www.geosci-model-dev.net/4/625/2011/ doi:10.5194/gmd-4-625-2011.

Wilson, Barry Tyler; Lister, Andrew J.; Riemann, Rachel I.; Griffith, Douglas M. 2013a. Live tree species basal area of the contiguous United States (2000-2009). Newtown Square, PA: USDA Forest Service, Rocky Mountain Research Station. https://doi.org/10.2737/RDS-2013-0013

Wilson, Barry Tyler; Woodall, Christopher W.; Griffith, Douglas M. 2013b. Forest carbon stocks of the contiguous United States (2000-2009). Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/RDS-2013-0004

WRAP / Ramboll, 2019. Revised Final Report: Circa-2014 Baseline Oil and Gas Emission Inventory for the WESTAR-WRAP Region, September 2019. Available at: http://www.wrapair2.org/pdf/WRAP_OGWG_Report_Baseline_17Sep2019.pdf.

WRAP / Ramboll, 2020. Revised Final Report: 2028 Future Year Oil and Gas Emission Inventory for WESTAR-WRAP States – Scenario #1: Continuation of Historical Trends http://www.wrapair2.org/pdf/WRAP_OGWG_2028_OTB_RevFinalReport_05March2020.pdf .

Yarwood, G., J. Jung, , G. Whitten, G. Heo, J. Mellberg, and M. Estes,2010: Updates to the Carbon Bond Chemical Mechanism for Version 6 (CB6). Presented at the 9th Annual CMAS Conference, Chapel Hill, NC. Available at https://www.cmascenter.org/conference/2010/abstracts/emery_updates_carbon_2010.pdf.

Zhu, Henze, et al, 2013. "Constraining U.S. Ammonia Emissions using TES Remote Sensing Observations and the GEOS-Chem adjoint model", Journal of Geophysical Research: Atmospheres, 118: 1-14. Available at https://doi.org/10.1002/jgrd.50166.

Appendix A: CB6 Assignment for New Species

RAMBOLL ENVIRON

September 27, 2016

MEMORANDUM

To: Alison Eyth and Madeleine Strum, OAQPS, EPA
From: Ross Beardsley and Greg Yarwood, Ramboll Environ
Subject: Species Mappings for CB6 and CB05 for use with SPECIATE 4.5

Summary

Ramboll Environ (RE) reviewed version 4.5 of the SPECIATE database, and created CB05 and CB6 mechanism species mappings for newly added compounds. In addition, the mapping guidelines for Carbon Bond (CB) mechanisms were expanded to promote consistency in current and future work.

Background

The Environmental Protection Agency's SPECIATE repository contains gas and particulate matter speciation profiles of air pollution sources, which are used in the generation of emissions data for air quality models (AQM) such as CMAQ (http://www.cmascenter.org/cmaq/) and CAMx (http://www.camx.com). However, the condensed chemical mechanisms used within these photochemical models utilize fewer species than SPECIATE to represent gas phase chemistry, and thus the SPECIATE compounds must be assigned to the AQM model species of the condensed mechanisms. A chemical mapping is used to show the representation of organic chemical species by the model compounds of the condensed mechanisms.

This memorandum describes how chemical mappings were developed from SPECIATE 4.5 compounds to model species of the CB mechanism, specifically CB05 (http://www.camx.com/publ/pdfs/CB05_Final_Report_120805.pdf) and CB6 (http://aqrp.ceer.utexas.edu/projectinfoFY12_13/12-012/12-012%20Final%20Report.pdf).

Methods

CB Model Species

Organic gases are mapped to the CB mechanism either as explicitly represented individual compounds (e.g. ALD2 for acetaldehyde), or as a combination of model species that represent common structural groups (e.g. ALDX for other aldehydes, PAR for alkyl groups). Table 1 lists all of the explicit and structural model species in CB05 and CB6 mechanisms, each of which represents a defined number of carbon atoms allowing for carbon to be conserved in all cases. CB6 contains four more explicit model species than CB05 and an additional structural group to represent ketones. The CB05 representation of the five additional CB6 species is provided in the '*Included in CB05*' column of Table 1.

Ramboll Environ, 773 San Marin Drive, Suite 2115, Novato, CA 94998
V +1 415.899.0700 F +1 415.899.0707
UNC-EMAQ(4-02)-16

In addition to the explicit and structural species, there are two model species that are used to represent organic gases that are not treated by the CB mechanism:

NVOL – Very low volatility SPECIATE compounds that reside predominantly in the particle phase and should be excluded from the gas phase mechanism. These compounds are mapped by setting NVOL equal to the molecular weight (e.g. decabromodiphenyl oxide is mapped as 959.2 NVOL), which allows for the total mass of all NVOL to be determined.

UNK – Compounds that are unable to be mapped to CB using the available model species. This approach should be avoided unless absolutely necessary, and will lead to a warning message in the speciation tool.

Table 1. Model species in the CB05 and CB6 chemical mechanisms.

Model Species Name	Description	Number of Carbons	Included in CB05 (structural mapping)	Included in CB6
Explicit model species				
ACET	Acetone (propanone)	3	No (3 PAR)	Yes
ALD2	Acetaldehyde (ethanal)	2	Yes	Yes
BENZ	Benzene	6	No (1 PAR, 5 UNR)	Yes
CH4	Methane	1	Yes	Yes
ETH	Ethene (ethylene)	2	Yes	Yes
ETHA	Ethane	2	Yes	Yes
ETHY	Ethyne (acetylene)	2	No (1 PAR, 1 UNR)	Yes
ETOH	Ethanol	2	Yes	Yes
FORM	Formaldehyde (methanal)	1	Yes	Yes
ISOP	Isoprene (2-methyl-1,3-butadiene)	5	Yes	Yes
MEOH	Methanol	1	Yes	Yes
PRPA	Propane	3	No (1.5 PAR, 1.5 UNR)	Yes
Common Structural groups				
ALDX	Higher aldehyde group (-C-CHO)	2	Yes	Yes
IOLE	Internal olefin group (R_1R_2>C=C<R_3R_4)	4	Yes	Yes
KET	Ketone group (R_1R_2 >C=O)	1	No (1 PAR)	Yes
OLE	Terminal olefin group (R_1R_2>C=C)	2	Yes	Yes
PAR	Paraffinic group (R_1-C<R_2R_3)	1	Yes	Yes
TERP	Monoterpenes	10	Yes	Yes
TOL	Toluene and other monoalkyl aromatics	7	Yes	Yes
UNR	Unreactive carbon groups (e.g., halogenated carbons)	1	Yes	Yes
XYL	Xylene and other polyalkyl aromatics	8	Yes	Yes
Not mapped to CB model species				
NVOL	Very low volatility compounds	*	Yes	Yes
UNK	Unknown	*	Yes	Yes

*Each NVOL represents 1 g mol^{-1} and low volatility compounds are assigned to NVOL based on molecular weight. UNK is unmapped and thus does not represent any carbon.

Mapping guidelines for non-explicit organic gases using CB model species

SPECIATE compounds that are not treated explicitly are mapped to CB model species that represent common structural groups. Table 2 lists the carbon number and general mapping guidelines for each of the structure model species.

Table 2. General Guidelines for mapping using CB6 structural model species.

CB6 Species Name	Number of Carbons	Represents
ALDX	2	Aldehyde group. ALDX represents 2 carbons and additional carbons are represented as alkyl groups (mostly PAR), e.g. propionaldehyde is ALDX + PAR
IOLE	4	Internal olefin group. IOLE represents 4 carbons and additional carbons are represented as alkyl groups (mostly PAR), e.g. 2-pentene isomers are IOLE + PAR. *Exceptions:* • IOLE with 2 carbon branches on both sides of the double bond are downgraded to OLE
KET	1	Ketone group. KET represents 1 carbon and additional carbons are represented as alkyl groups (mostly PAR), e.g. butanone is 3 PAR + KET
OLE	2	Terminal olefin group. OLE represents 2 carbons and additional carbons are represented as alkyl groups (mostly PAR), e.g. propene is OLE + PAR. Alkyne group, e.g. butyne isomers are OLE + 2 PAR.
PAR	1	Alkanes and alkyl groups. PAR represents 1 carbon, e.g. butane is 4 PAR. See UNR for exceptions.
TERP	10	All monoterpenes are represented as 1 TERP.
TOL	7	Toluene and other monoalkyl aromatics. TOL represents 7 carbons and any additional carbons are represented as alkyl groups (mostly PAR), e.g. ethylbenzene is TOL + PAR. Cresols are represented as TOL and PAR. Styrenes are represented using TOL, OLE and PAR.
UNR	1	Unreactive carbons are 1 UNR such as quaternary alkyl groups (e.g., neo-pentane is 4 PAR + UNR), carboxylic acid groups (e.g., acetic acid is PAR + UNR), ester groups (e.g., methyl acetate is 2 PAR + UNR), halogenated carbons (e.g., trichloroethane isomers are 2 UNR), carbons of nitrile groups (-C≡N).
XYL	8	Xylene isomers and other polyalkyl aromatics. XYL represents 8 carbons and any additional carbons are represented as alkyl groups (mostly PAR), e.g. trimethylbenzene isomers are XYL + PAR

Some compounds that are multifunctional and/or include hetero-atoms lack obvious CB mappings. We developed guidelines for some of these compound classes to promote consistent representation in this work and future revisions. Approaches for several compound classes are explained in Table 3. We developed guidelines as needed to address newly added species in SPECIATE 4.5 but did not systematically review existing mappings for "difficult to assign" compounds that could benefit from developing a guideline.

Table 3. Mapping guidelines for some difficult to map compound classes and structural groups

Compound Class/Structural group	CB model species representation
Chlorobenzenes and other halogenated benzenes	Guideline: • 3 or less halogens – 1 PAR, 5 UNR • 4 or more halogens – 6 UNR Examples: • 1,3,5-Chlorobenzene – 1 PAR, 5 UNR • Tetrachlorobenzenes – 6 UNR
Cyclodienes	Guideline: • 1 IOLE with additional carbons represented as alkyl groups (generally PAR) Examples: • Methylcyclopentadiene – 1 IOLE, 2 PAR • Methylcyclohexadiene – 1 IOLE, 3 PAR
Furans/Pyrroles	Guideline: • 2 OLE with additional carbons represented as alkyl groups (generally PAR) Examples: • 2-Butylfuran – 2 OLE, 4 PAR • 2-Pentylfuran – 2 OLE, 5 PAR • Pyrrole – 2 OLE • 1-Methylpyrrole – 2 OLE, 1 PAR
Heterocyclic aromatic compounds containing 2 non-carbon atoms	Guideline: • 1 OLE with remaining carbons represented as alkyl groups (generally PAR) Examples: • Ethylpyrazine – 1 OLE, 4 PAR • 1-methylpyrazole – 1 OLE, 2 PAR • 4,5-Dimethyloxazole – 1 OLE, 3 PAR
Triple bond(s)	Guideline: • Triple bonds are treated as PAR unless they are the only reactive functional group. If a compound contains more than one triple bond and no other reactive functional groups, then one of the triple bonds is treated as OLE with additional carbons treated as alkyl groups. Examples: • 1-Penten-3-yne – 1 OLE, 3 PAR • 1,5-Hexadien-3-yne – 2 OLE, 2 PAR • 1,6-Heptadiyne – 1 OLE, 5 PAR

These guidelines were used to map the new species from SPEICATE4.5, and also to revise some previously mapped compounds. Overall, a total of 175 new species from SPECIATEv4.5 were mapped and 7 previously mapped species were revised based on the new guidelines.

Recommendation

1. Complete a systematic review of the mapping of all species to ensure conformity with current mapping guidelines. The assignments of existing compounds that are similar to new species were reviewed and revised to promote consistency in mapping approaches, but the majority of existing species mappings were not reviewed as it was outside the scope of this work.
2. Develop a methodology for classifying and tracking larger organic compounds based on their volatility (semi, intermediate, or low volatility) to improve support for secondary organic aerosol (SOA) modeling using the volatility basis set (VBS) SOA model, which is available in both CMAQ and CAMx. A preliminary investigation of the possibility of doing so has been performed, and is discussed in a separate memorandum.

Appendix B: **Profiles (other than onroad) that are new or revised in SPECIATE versions 4.5 and later that were used in the 2016 platforms**

Table B-1 Profiles first used in 2016beta, 2016v1, and 2016v2 platforms

Sector	Pollutant	Profile code	Profile description	SPECIATE version
ptfire, ptagfire	VOC	G8746	Rice Straw and Wheat Straw Burning Composite of G4420 and G4421	5.0
livestock	VOC	G95241TOG	Swine Farm and Animal Waste with gapfilled methane and ethane	5.0
np_oilgas, pt_oilgas	VOC	UTUBOGC	Raw Gas from Oil Wells - Composite Uinta basin	5.1
np_oilgas, pt_oilgas	VOC	UTUBOGD	Raw Gas from Gas Wells - Composite Uinta basin	5.1
np_oilgas, pt_oilgas	VOC	UTUBOGE	Flash Gas from Oil Tanks - including Carbonyls - Composite Uinta basin	5.1
np_oilgas, pt_oilgas	VOC	UTUBOGF	Flash Gas from Condensate Tanks - including Carbonyls - Composite Uinta basin	5.1
np_oilgas, pt_oilgas	VOC	PAGAS01	Oil and Gas-Produced Gas Composition from Gas Wells-Greene Co, PA	5.1
np_oilgas, pt_oilgas	VOC	PAGAS02	Oil and Gas-Produced Gas Composition from Gas Wells-Butler Co, PA	5.1
np_oilgas, pt_oilgas	VOC	PAGAS03	Oil and Gas-Produced Gas Composition from Gas Wells-Washington Co, PA	5.1
np_oilgas, pt_oilgas	VOC	SUIROGCT	Flash Gas from Condensate Tanks - Composite Southern Ute Indian Reservation	5.2
np_oilgas, pt_oilgas	VOC	CBMPWWY	Coal Bed Methane Produced Water Profile - WY ponds	5.2
np_oilgas, pt_oilgas	VOC	DJTFLR95	DJ Condensate Flare Profile with DRE 95%	5.2
np_oilgas, pt_oilgas	VOC	CMU01	Oil and Gas - Produced Gas Composition from Gas Wells - Central Montana Uplift - Montana	5.1
np_oilgas, pt_oilgas	VOC	WIL01	Oil and Gas - Flash Gas Composition from Tanks at Oil Wells - Williston Basin North Dakota	5.1
np_oilgas, pt_oilgas	VOC	WIL02	Oil and Gas - Flash Gas Composition from Tanks at Oil Wells - Williston Basin Montana	5.1
np_oilgas, pt_oilgas	VOC	WIL03	Oil and Gas - Produced Gas Composition from Oil Wells - Williston Basin North Dakota	5.1
np_oilgas, pt_oilgas	VOC	WIL04	Oil and Gas - Produced Gas Composition from Oil Wells - Williston Basin Montana	5.1
cmv_c1c2, cmv_c3	VOC	95331NEIHP	Marine Vessel - 95331 blend with CMV HAP	5.1
ptagfire	PM	SUGP02	Sugar Cane Pre-Harvest Burning Mexico	5.1
ptfire	PM	95793	Forest Fire-Flaming-Oregon AE6	5.1
ptfire	PM	95794	Forest Fire-Smoldering-Oregon AE6	5.1
ptfire	PM	95798	Forest Fire-Flaming-North Carolina AE6	5.1

Sector	Pollutant	Profile code	Profile description	SPECIATE version
ptfire	PM	95799	Forest Fire-Smoldering-North Carolina AE6	5.1
ptfire	PM	95804	Forest Fire-Flaming-Montana AE6	5.1
ptfire	PM	95805	Forest Fire-Smoldering-Montana AE6	5.1
ptfire	PM	95807	Forest Fire Understory-Flaming-Minnesota AE6	5.1
ptfire	PM	95808	Forest Fire Understory-Smoldering-Minnesota AE6	5.1
ptfire	PM	95809	Grass Fire-Field-Kansas AE6	5.1

Table B-2 Profiles first used in 2016 alpha platform

Sector	Pollutant	Profile code	Profile description	SPECIATE version	Comment
nonpt	VOC	G95223TOG	Poultry Production - Average of Production Cycle with gapfilled methane and ethane	5.0	Replacement for v4.5 profile 95223; Used 70% methane, 20% ethane, and the 10% remaining VOC is from profile 95223
Nonpt, ptnonipm	VOC	G95240TOG	Beef Cattle Farm and Animal Waste with gapfilled methane and ethane	5.0	Replacement for v4.5 profile 95240. Used 70% methane, 20% ethane; the 10% remaining VOC is from profile 95240.
nonpt	VOC	G95241TOG	Swine Farm and Animal Waste	5.0	Replacement for v4.5 profile 95241. Used 70% methane, 20% ethane; the 10% remaining VOC is from profile 95241
nonpt, ptnonipm, pt_oilgas, ptegu	PM2.5	95475	Composite -Refinery Fuel Gas and Natural Gas Combustion	5.0	Composite of AE6-ready versions of SPECIATE4.5 profiles 95125, 95126, and 95127
nonroad	VOC	95328	Spark-Ignition Exhaust Emissions from 2-stroke off-road engines - E10 ethanol gasoline	4.5	
nonroad	VOC	95330	Spark-Ignition Exhaust Emissions from 4-stroke off-road engines - E10 ethanol gasoline	4.5	
nonroad	VOC	95331	Diesel Exhaust Emissions from Pre-Tier 1 Off-road Engines	4.5	
nonroad	VOC	95332	Diesel Exhaust Emissions from Tier 1 Off-road Engines	4.5	
nonroad	VOC	95333	Diesel Exhaust Emissions from Tier 2 Off-road Engines	4.5	
np_oilgas	VOC	95087a	Oil and Gas - Composite - Oil Field - Oil Tank Battery Vent Gas	4.5	
np_oilgas	VOC	95109a	Oil and Gas - Composite - Oil Field - Condensate Tank Battery Vent Gas	4.5	
np_oilgas	VOC	95398	Composite Profile - Oil and Natural Gas Production - Condensate Tanks	4.5	

Sector	Pollutant	Profile code	Profile description	SPECIATE version	Comment
np_oilgas	VOC	95403	Composite Profile - Gas Wells	4.5	
np_oilgas	VOC	95417	Oil and Gas Production - Composite Profile - Untreated Natural Gas, Uinta Basin	4.5	
np_oilgas	VOC	95418	Oil and Gas Production - Composite Profile - Condensate Tank Vent Gas, Uinta Basin	4.5	
np_oilgas	VOC	95419	Oil and Gas Production - Composite Profile - Oil Tank Vent Gas, Uinta Basin	4.5	
np_oilgas	VOC	95420	Oil and Gas Production - Composite Profile - Glycol Dehydrator, Uinta Basin	4.5	
np_oilgas	VOC	DJVNT_R	Oil and Gas -Denver-Julesburg Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
np_oilgas	VOC	FLR99	Natural Gas Flare Profile with DRE >98%	4.5	
np_oilgas	VOC	PNC01_R	Oil and Gas -Piceance Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
np_oilgas	VOC	PNC02_R	Oil and Gas -Piceance Basin Produced Gas Composition from Oil Wells	4.5	
np_oilgas	VOC	PNC03_R	Oil and Gas -Piceance Basin Flash Gas Composition for Condensate Tank	4.5	
np_oilgas	VOC	PNCDH	Oil and Gas Production - Composite Profile - Glycol Dehydrator, Piceance Basin	4.5	
np_oilgas	VOC	PRBCB_R	Oil and Gas -Powder River Basin Produced Gas Composition from CBM Wells	4.5	
np_oilgas	VOC	PRBCO_R	Oil and Gas -Powder River Basin Produced Gas Composition from Non-CBM Wells	4.5	
np_oilgas	VOC	PRM01_R	Oil and Gas -Permian Basin Produced Gas Composition for Non-CBM Wells	4.5	
np_oilgas	VOC	SSJCB_R	Oil and Gas -South San Juan Basin Produced Gas Composition from CBM Wells	4.5	
np_oilgas	VOC	SSJCO_R	Oil and Gas -South San Juan Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
np_oilgas	VOC	SWFLA_R	Oil and Gas -SW Wyoming Basin Flash Gas Composition for Condensate Tanks	4.5	
np_oilgas	VOC	SWVNT_R	Oil and Gas -SW Wyoming Basin Produced Gas Composition from Non-CBM Wells	4.5	
np_oilgas	VOC	UNT01_R	Oil and Gas -Uinta Basin Produced Gas Composition from CBM Wells	4.5	
np_oilgas	VOC	WRBCO_R	Oil and Gas -Wind River Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
pt_oilgas	VOC	95325	Chemical Manufacturing Industry Wide Composite	4.5	
pt_oilgas	VOC	95326	Pulp and Paper Industry Wide Composite	4.5	
pt_oilgas, ptnonipm	VOC	95399	Composite Profile - Oil Field - Wells	4.5	
pt_oilgas	VOC	95403	Composite Profile - Gas Wells	4.5	
pt_oilgas	VOC	95417	Oil and Gas Production - Composite Profile - Untreated Natural Gas, Uinta Basin	4.5	

Sector	Pollutant	Profile code	Profile description	SPECIATE version	Comment
pt_oilgas	VOC	DJVNT_R	Oil and Gas -Denver-Julesburg Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
pt_oilgas, ptnonipm	VOC	FLR99	Natural Gas Flare Profile with DRE >98%	4.5	
pt_oilgas	VOC	PNC01_R	Oil and Gas -Piceance Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
pt_oilgas	VOC	PNC02_R	Oil and Gas -Piceance Basin Produced Gas Composition from Oil Wells	4.5	
pt_oilgas	VOC	PNCDH	Oil and Gas Production - Composite Profile - Glycol Dehydrator, Piceance Basin	4.5	
pt_oilgas, ptnonipm	VOC	PRBCO_R	Oil and Gas -Powder River Basin Produced Gas Composition from Non-CBM Wells	4.5	
pt_oilgas, ptnonipm	VOC	PRM01_R	Oil and Gas -Permian Basin Produced Gas Composition for Non-CBM Wells	4.5	
pt_oilgas, ptnonipm	VOC	SSJCO_R	Oil and Gas -South San Juan Basin Produced Gas Composition from Non-CBM Gas Wells	4.5	
pt_oilgas, ptnonipm	VOC	SWVNT_R	Oil and Gas -SW Wyoming Basin Produced Gas Composition from Non-CBM Wells	4.5	
ptfire	VOC	95421	Composite Profile - Prescribed fire southeast conifer forest	4.5	
ptfire	VOC	95422	Composite Profile - Prescribed fire southwest conifer forest	4.5	
ptfire	VOC	95423	Composite Profile - Prescribed fire northwest conifer forest	4.5	
ptfire	VOC	95424	Composite Profile - Wildfire northwest conifer forest	4.5	
ptfire	VOC	95425	Composite Profile - Wildfire boreal forest	4.5	
ptnonipm	VOC	95325	Chemical Manufacturing Industry Wide Composite	4.5	
ptnonipm	VOC	95326	Pulp and Paper Industry Wide Composite	4.5	
onroad	PM2.5	95462	Composite - Brake Wear	4.5	Used in SMOKE-MOVES
onroad	PM2.5	95460	Composite - Tire Dust	4.5	Used in SMOKE-MOVES

Appendix C: Mapping of Fuel Distribution SCCs to BTP, BPS and RBT

The table below provides a crosswalk between fuel distribution SCCs and classification type for portable fuel containers (PFC), fuel distribution operations associated with the bulk-plant-to-pump (BTP), refinery to bulk terminal (RBT) and bulk plant storage (BPS).

SCC	Type	Description
40301001	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 13: Breathing Loss (67000 Bbl. Tank Size)
40301002	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 10: Breathing Loss (67000 Bbl. Tank Size)
40301003	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 7: Breathing Loss (67000 Bbl. Tank Size)
40301004	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 13: Breathing Loss (250000 Bbl. Tank Size)
40301006	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 7: Breathing Loss (250000 Bbl. Tank Size)
40301007	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Fixed Roof Tanks (Varying Sizes); Gasoline RVP 13: Working Loss (Tank Diameter Independent)
40301101	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline RVP 13: Standing Loss (67000 Bbl. Tank Size)
40301102	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline RVP 10: Standing Loss (67000 Bbl. Tank Size)
40301103	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline RVP 7: Standing Loss (67000 Bbl. Tank Size)
40301105	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline RVP 10: Standing Loss (250000 Bbl. Tank Size)
40301151	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Floating Roof Tanks (Varying Sizes); Gasoline: Standing Loss - Internal
40301202	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Variable Vapor Space; Gasoline RVP 10: Filling Loss
40301203	RBT	Petroleum and Solvent Evaporation; Petroleum Product Storage at Refineries; Variable Vapor Space; Gasoline RVP 7: Filling Loss
40400101	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank
40400102	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank
40400103	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Breathing Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400104	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank
40400105	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Breathing Loss (250000 Bbl Capacity)-Fixed Roof Tank
40400106	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Breathing Loss (250000 Bbl Capacity) - Fixed Roof Tank
40400107	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Working Loss (Diam. Independent) - Fixed Roof Tank
40400108	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Working Loss (Diameter Independent) - Fixed Roof Tank
40400109	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Working Loss (Diameter Independent) - Fixed Roof Tank
40400110	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank

SCC	Type	Description
40400111	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss (67000 Bbl Capacity)-Floating Roof Tank
40400112	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss (67000 Bbl Capacity)- Floating Roof Tank
40400113	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank
40400114	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank
40400115	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss (250000 Bbl Cap.) - Floating Roof Tank
40400116	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl Cap.) - Float Rf Tnk
40400117	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13/10/7: Withdrawal Loss (250000 Bbl Cap.) - Float Rf Tnk
40400118	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400119	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400120	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400130	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Standing Loss - External Floating Roof w/ Primary Seal
40400131	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Primary Seal
40400132	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Primary Seal
40400133	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss - External Floating Roof w/ Primary Seal
40400140	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Standing Loss - Ext. Float Roof Tank w/ Secondy Seal
40400141	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400142	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400143	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400148	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13/10/7: Withdrawal Loss - Ext. Float Roof (Pri/Sec Seal)
40400149	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: External Floating Roof (Primary/Secondary Seal)
40400150	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Miscellaneous Losses/Leaks: Loading Racks
40400151	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Valves, Flanges, and Pumps
40400152	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Vapor Collection Losses
40400153	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Vapor Control Unit Losses
40400160	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Standing Loss - Internal Floating Roof w/ Primary Seal
40400161	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Primary Seal
40400162	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Primary Seal

SCC	Type	Description
40400163	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss - Internal Floating Roof w/ Primary Seal
40400170	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400171	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400172	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400173	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 7: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400178	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Gasoline RVP 13/10/7: Withdrawal Loss - Int. Float Roof (Pri/Sec Seal)
40400179	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals; Specify Liquid: Internal Floating Roof (Primary/Secondary Seal)
40400199	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Terminals;
40400201	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank
40400202	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Breathing Loss (67000 Bbl Capacity) - Fixed Roof Tank
40400203	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Breathing Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400204	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400205	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400206	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Working Loss (67000 Bbl. Capacity) - Fixed Roof Tank
40400207	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss (67000 Bbl Cap.) - Floating Roof Tank
40400208	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Standing Loss (67000 Bbl Cap.) - Floating Roof Tank
40400210	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13/10/7: Withdrawal Loss (67000 Bbl Cap.) - Float Rf Tnk
40400211	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400212	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space
40400213	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Filling Loss (10500 Bbl Cap.) - Variable Vapor Space

SCC	Type	Description
40400230	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Standing Loss - External Floating Roof w/ Primary Seal
40400231	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Primary Seal
40400232	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Standing Loss - Ext. Floating Roof w/ Primary Seal
40400233	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Standing Loss - External Floating Roof w/ Primary Seal
40400240	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400241	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss - Ext. Floating Roof w/ Secondary Seal
40400248	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10/13/7: Withdrawal Loss - Ext. Float Roof (Pri/Sec Seal)
40400249	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: External Floating Roof (Primary/Secondary Seal)
40400250	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Loading Racks
40400251	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Valves, Flanges, and Pumps
40400252	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Miscellaneous Losses/Leaks: Vapor Collection Losses
40400253	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Miscellaneous Losses/Leaks: Vapor Control Unit Losses
40400260	RBT	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Standing Loss - Internal Floating Roof w/ Primary Seal
40400261	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Primary Seal
40400262	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Primary Seal
40400263	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Standing Loss - Internal Floating Roof w/ Primary Seal
40400270	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400271	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 13: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400272	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10: Standing Loss - Int. Floating Roof w/ Secondary Seal

SCC	Type	Description
40400273	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 7: Standing Loss - Int. Floating Roof w/ Secondary Seal
40400278	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Gasoline RVP 10/13/7: Withdrawal Loss - Int. Float Roof (Pri/Sec Seal)
40400279	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Bulk Plants; Specify Liquid: Internal Floating Roof (Primary/Secondary Seal)
40400401	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 13: Breathing Loss
40400402	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 13: Working Loss
40400403	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 10: Breathing Loss
40400404	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 10: Working Loss
40400405	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 7: Breathing Loss
40400406	BTP /BPS	Petroleum and Solvent Evaporation; Petroleum Liquids Storage (non-Refinery); Petroleum Products - Underground Tanks; Gasoline RVP 7: Working Loss
40600101	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Splash Loading
40600126	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Submerged Loading
40600131	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Submerged Loading (Normal Service)
40600136	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Splash Loading (Normal Service)
40600141	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Submerged Loading (Balanced Service)
40600144	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Splash Loading (Balanced Service)
40600147	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Submerged Loading (Clean Tanks)
40600162	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Loaded with Fuel (Transit Losses)
40600163	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Gasoline: Return with Vapor (Transit Losses)

SCC	Type	Description
40600199	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Tank Cars and Trucks; Not Classified
40600231	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Tankers: Cleaned and Vapor Free Tanks
40600232	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Tankers
40600233	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Barges: Cleaned and Vapor Free Tanks
40600234	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Tankers: Ballasted Tank
40600235	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Ocean Barges Loading - Ballasted Tank
40600236	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Tankers: Uncleaned Tanks
40600237	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Ocean Barges Loading - Uncleaned Tanks
40600238	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Barges: Uncleaned Tanks
40600239	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Tankers: Ballasted Tank
40600240	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Loading Barges: Average Tank Condition
40600241	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Gasoline: Tanker Ballasting
40600299	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Marine Vessels; Not Classified
40600301	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Splash Filling
40600302	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Submerged Filling w/o Controls
40600305	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Unloading
40600306	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Balanced Submerged Filling
40600307	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Underground Tank Breathing and Emptying
40600399	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Gasoline Retail Operations - Stage I; Not Classified **
40600401	BTP/BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Filling Vehicle Gas Tanks - Stage II; Vapor Loss w/o Controls
40600501	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Pipeline Petroleum Transport - General - All Products; Pipeline Leaks

SCC	Type	Description
40600502	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Pipeline Petroleum Transport - General - All Products; Pipeline Venting
40600503	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Pipeline Petroleum Transport - General - All Products; Pump Station
40600504	RBT	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Pipeline Petroleum Transport - General - All Products; Pump Station Leaks
40600602	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage II; Liquid Spill Loss w/o Controls
40600701	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage I; Splash Filling
40600702	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage I; Submerged Filling w/o Controls
40600706	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage I; Balanced Submerged Filling
40600707	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Consumer (Corporate) Fleet Refueling - Stage I; Underground Tank Breathing and Emptying
40688801	BTP /BPS	Petroleum and Solvent Evaporation; Transportation and Marketing of Petroleum Products; Fugitive Emissions; Specify in Comments Field
2501050120	RBT	Storage and Transport; Petroleum and Petroleum Product Storage; Bulk Terminals: All Evaporative Losses; Gasoline
2501055120	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Bulk Plants: All Evaporative Losses; Gasoline
2501060050	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Total
2501060051	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Submerged Filling
2501060052	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Splash Filling
2501060053	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Stage 1: Balanced Submerged Filling
2501060200	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Underground Tank: Total
2501060201	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; Gasoline Service Stations; Underground Tank: Breathing and Emptying
2501995000	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Storage; All Storage Types: Working Loss; Total: All Products
2505000120	RBT	Storage and Transport; Petroleum and Petroleum Product Transport; All Transport Types; Gasoline
2505020120	RBT	Storage and Transport; Petroleum and Petroleum Product Transport; Marine Vessel; Gasoline

SCC	Type	Description
2505020121	RBT	Storage and Transport; Petroleum and Petroleum Product Transport; Marine Vessel; Gasoline - Barge
2505030120	BTP /BPS	Storage and Transport; Petroleum and Petroleum Product Transport; Truck; Gasoline
2505040120	RBT	Storage and Transport; Petroleum and Petroleum Product Transport; Pipeline; Gasoline
2660000000	BTP /BPS	Waste Disposal, Treatment, and Recovery; Leaking Underground Storage Tanks; Leaking Underground Storage Tanks; Total: All Storage Types

United States Environmental Protection Agency	Office of Air Quality Planning and Standards Air Quality Assessment Division Research Triangle Park, NC	Publication No. EPA-454/B-23-001 January 2023