Technical Support Document (TSD): Preparation of Emissions Inventories for the 2016v2 North American Emissions Modeling Platform

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Technical Support Document (TSD): Preparation of Emissions Inventories for the 2016v2 North American Emissions Modeling Platform

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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 (emission mode used in SMOKE-MOVES)
RPP	Rate-per-profile (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 updated the 2016v1 emissions modeling platform developed by the National Emissions Inventory Collaborative to incorporate updated data, models, and methods to create a 2016v2 emissions modeling platform. The 2016v2 platform is designed to be used studies focused on criteria air pollutants and represents the years of 2016, 2023 2026, and 2032. The 2016v2 platform draws on data from the 2017 National Emissions Inventory (NEI), although the inventory was 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 future year inventories were developed starting with the base year 2016 inventory using sector-specific methods as described below. The 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 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 1.0. This 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., 7.3 where 7 represents 2014-2016 NEI-based platforms, and 3 means the third iteration of the platform). As an evolution of the 2016v1 platform, the 2016v2 platform is also known as the v7.4 platform. The specification sheets posted on the 2016v1 platform release page (http://views.cira.colostate.edu/wiki/wiki/10202) provide some additional details regarding the inventories and emissions modeling techniques that are relevant for the 2016v2 platform in addition to those addressed in this TSD.

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 2016v2 platform consists of cases that represent the years 2016, 2023 case, 2026, and 2032 case with the abbreviations **2016fj_16j, 2023fj_16j, 2023fj_16j** and **2032_16j**, respectively. Derivatives of these cases that included source apportionment by state and in some cases by inventory sector 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, where f is for the

2016 platform that 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 "2016fj_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. Temporal, spatial and other changes in emissions between the NEI and the emissions input into the platform are described primarily in the platform specification sheets, although 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 4.8.1 (SMOKE 4.8.1) with some updates. 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 future 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 2016v2 platform. This section provides details about the data contained in each of the platform sectors for the base year and the future year. The original starting point for the emission inventories was the 2016v1 platform. The 2016v1 data were updated with information and methods from the 2017 NEI, MOVES3, and updated inventory methodologies. 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, 2021). Documentation for each 2016v1 emissions sector in the form of specification sheets is available on the 2016v1 page of Inventory Collaborative Wiki (http://views.cira.colostate.edu/wiki/wiki/10202) provides additional details of data provided for the 2016v1 process. 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 2016v2.

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. All emissions modeling sectors were modified in some way to better represent the year 2016 for the 2016v2 platform.

For interim years other than triennial NEI years, point source data are 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, along with adjusted 2014 data pulled forward for sources under the annual reporting threshold with the goal of better representing emissions in 2016. Most of the point sources in 2016v2 are consistent with those in 2016v1. Agricultural and wildland fire emissions represent the year 2016 and are mostly consistent with those in 2016v1. In 2016v2, emissions for nonpoint source sectors started with 2017 NEI emissions and were adjusted to better represent the year 2016, as opposed to 2016v1 where these sectors were based on 2014 NEI data. Fertilizer emissions, nonpoint oil and gas emissions, and onroad and nonroad mobile source emissions represent the year 2016 and were updated from 2016v1. CMV emissions are consistent with 2016v1 and were developed based on 2017 NEI CMV emissions and the sulfur dioxide (SO_2) emissions reflect rules that reduced sulfur emissions for CMV that took effect in the year 2015. Locomotive emissions in the rail and ptnonipm sectors are consistent with those in 2016v1. Nonpoint oil and gas emissions were developed using 2016-specific data for oil and gas wells and their 2016 production levels.

Onroad and nonroad mobile source emissions were developed using the Motor Vehicle Emission Simulator (MOVES) and were updated from 2016v1. Onroad emissions for the platform 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. MOVES3 was also used to generate nonroad emissions using spatial allocation factors 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 (Mrggrid). The final merge program combines the sector-specific gridded, speciated, hourly emissions together to create CMAQ-ready emission inputs. For studies that use CAMx, these CMAQ-ready emissions inputs are converted into the file formats needed by CAMx.

In addition to the NEI-based sectors, emissions for Canada and Mexico are included. In 2016v2, 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.

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 minor 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 raw inventory. 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 from 2016v1 including S/L/T updates for oil and gas production and related processes and updated from 2016v1 with the Western Regional Air Partnership (WRAP) 2014 inventory. The sector 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). Oil and gas point sources that were not already updated to year 2016 in the baseline inventory were projected from 2014 to 2016. 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 2017 NEI data and backcast to 2016. Corrected from the 2016v1 version which had some double counting.

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
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 for 2016v1 and some additional sources that were not operating in 2016 but did operate in later years. Updates from 2016v1 were minor in that a few sources moved to ptegu. NOx control efficiencies were updated where new information was available. Year 2016 rail yard emissions were developed by the 2016v1 rail workgroup. Annual resolution.
Agricultural fertilizer: *fertilizer*	Nonpoint	Nonpoint agricultural fertilizer application emissions updated from 2016v1 and including only ammonia and estimated for 2016 using the FEST-C model and captured from a run of CMAQ for 2016. County and monthly resolution.
Agricultural Livestock: *livestock*	Nonpoint	Nonpoint agricultural livestock emissions including ammonia and other pollutants (except $PM_{2.5}$) updated from 2016v1 and backcast from 2017NEI based on animal population data from the U.S. Department of Agriculture (USDA) National Agriculture Statistics Service Quick Stats, where available. County and annual resolution.
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. Data are unchanged from 2016v1. 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 updated from 2016v1 and 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’. County and annual resolution.
Biogenic: *beis*	Nonpoint	Year 2016, hour-specific, grid cell-specific emissions generated from the BEIS3.7 model within SMOKE, including emissions in Canada and Mexico using BELD5 land use data. Updated from 2016v1 and consistent with 2017NEI methods.
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. Emissions unchanged from 2016v1 January 2020 version of CMV. Includes C1C2 emissions in U.S. state and Federal waters along with all non-U.S. C1C2 emissions including those in Canadian waters. 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, along with all non-U.S. C3 emissions including those in Canadian waters. Emissions are consistent with 2016v1 January 2020 version of CMV and 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. Gridded and hourly resolution.

Platform Sector: ***abbreviation***	**NEI Data Category**	**Description and resolution of the data input to SMOKE**
Locomotives : ***rail***	Nonpoint	Line haul rail locomotives emissions developed by the 2016v1 rail workgroup based on 2016 activity and emission factors and are unchanged from 2016v1. Includes freight and commuter rail emissions and incorporates state and local feedback. County and annual resolution.
Solvents : ***solvents***	Nonpoint (some Point)	VOC emissions from solvents for 2016 derived using the VCPy framework (Seltzer et al., 2021). Includes cleaners, personal care products, adhesives, architectural coatings, and aerosol coatings, industrial coatings, allied paint products, printing inks, dry-cleaning emissions, and agricultural pesticides. County and annual resolution.
Nonpoint source oil and gas: ***np_oilgas***	Nonpoint	2016 nonpoint oil and gas emissions updated from 2016v1. Based on output from the 2017NEI version of the Oil and Gas tool along with the 2014 WRAP oil and gas inventory and Pennsylvania's unconventional well inventory. Specifically, for the seven WRAP states we used the production-related emissions from the 2014 WRAP inventory. For the exploration-related emissions for these seven WRAP states we used the emissions from the 2017NEI version of the Oil and Gas Tool. County and annual resolution.
Residential Wood Combustion: ***rwc***	Nonpoint	2017 NEI nonpoint sources from residential wood combustion (RWC) processes backcast to the year 2016 (updated from 2016v1). County and annual resolution.
Remaining nonpoint: ***nonpt***	Nonpoint	Nonpoint sources not included in other platform sectors and updated from 2016v1 with 2017NEI data. 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. 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 winter and summer MOVES emissions tables produced by MOVES3 (updated from 2016v1) coupled with activity data backcast from 2017NEI to year 2016 or provided for 2016v1 by S/L/T agencies. SMOKE-MOVES was used to compute emissions from the emission factors and activity data. 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.
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 results updated from 2016v1. Volatile organic compound (VOC) HAP emissions derived from California-provided VOC emissions and MOVES-based speciation.

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
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). Incorporates state inputs and a few corrections from 2016v1. 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. Unchanged from 2016v1. 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. County and annual resolution.
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. 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. 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. 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 updated from 2016v1. Data were forced into 2D low-level emissions to reduce the size of othpt. Point oil and gas sources which are subject to plume rise are in the othpt sector. 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: monthly for nonroad sources; annual for rail and other nonpoint Canada sectors. Year 2016 Mexico (municipio resolution) emissions from their 2016 inventory: annual nonpoint and nonroad mobile inventories.

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
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. 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). Monthly resolution.

Other natural emissions are also merged in with the above sectors: ocean chlorine and sea salt. 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.

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/2014-2016-version-7-air-emissions-modeling-platforms, under the section entitled "2016v2 Platform". The platform informational text file indicates the particular zipped files associated with each platform sector. A number of reports (i.e., summaries) are available with 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.

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 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.

The point source file used for the modeling platform is exported from EIS into the Flat File 2010 (FF10) format that is compatible with SMOKE (see https://www.cmascenter.org/smoke/documentation/4.8.1/html/ch08s02s08.html). For the 2016v2 platform, the export of point source emissions, including stack parameters and locations from EIS, was done on June 12, 2018, and specific modifications were made since that time. 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 four NEI-based platform point source sectors: 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 sector also called 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. Additional information on updates made through the collaborative process is available in the collaborative specification sheets.

The EGU emissions are split out from the other sources to facilitate the use of distinct SMOKE temporal processing and future-year projection techniques. The oil and gas sector emissions (pt_oilgas) were processed separately for summary tracking purposes and distinct future-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 Naphthalene, Benzene, Acetaldehyde, Formaldehyde, and Methanol (NBAFM) species are based on speciation in 2016v2. 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, IPM region- and pollutant-specific diurnal profiles were applied to create hourly emissions.

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 5/28/2021). 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**. The retained 2014 NEIv2 EGUs in 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. 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 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 temporalization to hourly values.

In the SMOKE point flat 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 http://ampd.epa.gov/ampd/ near the bottom of the "Prepackaged Data" tab. 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 detail 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,[1] 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. MWC and cogeneration units 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 at some units. This issue was corrected in 2016v2.

[1] 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.

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 2-2. 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).

In addition, 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 2-3. 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 for sources with values found to be defaults. Release points for the agencies with the values shown in Table 2-4were replaced with values from the PSTK file for the respective SCCs. 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. Point source oil and gas sector NAICS Codes

NAICS	Type of point source	NAICS description
2111, 21111	Production	Oil and Gas Extraction
211111	Production	Crude Petroleum and Natural Gas Extraction
211112	Production	Natural Gas Liquid Extraction
213111	Production	Drilling Oil and Gas Wells
213112	Support	Support Activities for Oil and Gas Operations
2212, 22121, 221210	Distribution	Natural Gas Distribution
4862, 48621, 486210	Transmission	Pipeline Transportation of Natural Gas
48611, 486110	Transmission	Pipeline Transportation of Crude Oil

Table 2-3. 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

State+county FIPS	Facility ID	Facility Name
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

Table 2-4. Default stack parameter replacements

Dataset ID	stkdiam	stkhgt	stktemp	stkvel
2014CODPHE	0.1 ft	1 ft	70 degF or 72 degF	
2014PADEP	0.1 ft	1 ft	70 degF	0.1 ft/s or 1000 ft/s
2016LADEQ	0.3 ft		70 degF or 77 degF	0.1 ft/s
2016ILEPA	0.33 ft	33 ft or 35 ft	70 degF	
2016TXCEQ	1 ft or 3 ft	40 ft	72 degF	0.1 ft/s
2014NVBAQ		32.8 ft	72 degF	
2016WIDNR		20 ft		3.281 ft/s
2016MIDEQ			70 degF or 72 degF	
2016MNPCA			70 degF	
2016IADNR			68 degF or 70 degF	
2014ORDEQ			72 degF	
2014MSDEQ			72 degF	
2016SCDEQ			72 degF	1 ft/s
2014NCDAQ			72 degF	0.2 ft/s
2016INDEM			0 degF	0 ft/s
2016NEDEQ			350 degF	1.6666 ft/s
2014KYDAQ				0 ft/s
2016WYDEQ				11.46 ft/s

The starting point for the 2016v2 emissions platform pt_oilgas inventory was the 2016 point source NEI. The 2016 NEI includes data submitted by S/L/T agencies and EPA to the EIS for Type A (i.e., large) point sources. Point sources in the 2014 NEIv2 not submitted for 2016 were pulled forward from the 2014 NEIv2 unless they had been marked as shut down. For the federally-owned offshore point inventory of oil and gas platforms, a 2014 inventory was developed by the U.S. Department of the Interior, Bureau of Ocean and Energy Management, Regulation, and Enforcement (BOEM).

The 2016 pt_oilgas inventory includes sources with updated data for 2016 and sources carried forward from the 2014NEIv2 point inventory. Each type of source can be identified based on the calc_year field in the flat file 2010 (FF10) formatted inventory files, which is set to either 2016 or 2014. The pt_oilgas inventory was split into two components: one for 2016 sources, and one for 2014 sources. The 2016 sources were used in 2016v1 platform without further modification. Updates were made to selected West Virginia Type B facilities based on comments from the state.

For pt_oilgas emissions that were carried forward from the 2014NEIv2, the 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 for which the WRAP inventory was used are included in this table for reference, but their factors were not used. Table 2-6 shows the national emissions for pt_oilgas following the projection 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%
Arkansas	-26.7%	13.6%	-6.6%
California	-14.2%	-9.1%	-11.7%
Colorado (not used)	3.5%	22.0%	12.8%
Florida	8.0%	-13.2%	-2.6%
Idaho	0.0%	0.0%	0.0%
Illinois	13.2%	-9.5%	1.8%
Indiana	-6.2%	-27.5%	-16.9%
Kansas	-15.0%	-23.4%	-19.2%
Kentucky	-1.6%	-23.1%	-12.4%
Louisiana	-11.0%	-17.4%	-14.2%
Maryland	70.0%	N/A	N/A
Michigan	-12.6%	-23.4%	-18.0%

State	Natural Gas growth	Oil growth	Combination gas/oil growth
Mississippi	-10.9%	-16.3%	-13.6%
Missouri	-66.7%	-37.2%	-52.0%
Montana (not used)	-11.9%	-22.5%	-17.2%
Nebraska	27.3%	-25.0%	1.2%
Nevada	0.0%	-12.3%	-6.2%
New Mexico (not used)	1.4%	17.4%	9.4%
New York	-33.4%	-36.8%	-35.1%
North Dakota (not used)	31.4%	-4.3%	13.6%
Ohio	181.0%	44.4%	112.7%
Oklahoma	5.9%	6.9%	6.4%
Oregon	-18.0%	N/A	N/A
Pennsylvania	24.8%	-7.9%	8.5%
South Dakota (not used)	-33.9%	-21.7%	-27.8%
Tennessee	-31.9%	-22.1%	-27.0%
Texas	-6.1%	1.0%	-2.6%
Utah	-19.8%	-25.4%	-22.6%
Virginia	-10.0%	-50.0%	-30.0%
West Virginia	28.9%	0.7%	14.8%
Wyoming (not used)	-7.5%	-4.7%	-6.1%

Table 2-6. 2016fh pt_oilgas national emissions (excluding offshore) before and after 2014-to-2016 projections in non-WRAP States (tons/year)

Pollutant	Before projections	After projections	% change 2014 to 2016
CO	141,583	142,562	0.7%
NH3	292	283	-2.9%
NOX	325,703	326,870	0.4%
PM10-PRI	10,745	10,675	-0.7%
PM25-PRI	9,770	9,699	-0.7%
SO2	24,983	24,691	-1.2%
VOC	90,482	91,435	1.1%

The state of Pennsylvania provided new emissions data for natural gas transmission sources for year 2016. The PA point source data replaced the emissions used in 2016beta. Table 2-7 illustrates the change in emissions with this update.

Table 2-7. Pennsylvania emissions changes for natural gas transmission sources (tons/year).

State	State FIPS	NAICS	Pollutant	2016 beta	2016 v1	2016v1 – beta
Pennsylvania	42	486210	CO	2,787	2,385	403
Pennsylvania	42	486210	NOX	5,737	5,577	160
Pennsylvania	42	486210	PM10-PRI	400	227	173
Pennsylvania	42	486210	PM25-PRI	399	209	191

State	State FIPS	NAICS	Pollutant	2016 beta	2016 v1	2016v1 – beta
Pennsylvania	42	486210	SO2	30	33	-3
Pennsylvania	42	486210	VOC	1,221	1,149	71

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 2016v2 platform have been updated from the 2016 NEI point inventory and 2016v1 with the following changes.

<u>Updates in 2016v2 platform as compared to 2016v1</u>

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 2-4. The affected states were Colorado, Illinois, Iowa, Kentucky, Louisiana, Michigan, Mississippi, Nebraska, New Mexico, North Carolina, Oregon, Pennsylvania, South Carolina, Texas, Wisconsin, and Wyoming.

Other changes in 2016v2 ptnonipm from 2016v1 were:

- 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 overlapping the new solvents sector were removed (i.e., SCCs starting with 24 which have a Tier 1 description of "Solvent utilization" – including surface coatings, graphic arts, personal care products, household products, and pesticide applications).
- 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.
- 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.

The following subsections describe the development of the 2016v1 ptnonipm sources.

Non-IPM Projection from 2014 to 2016 inside MARAMA region

2014-to-2016 projection packets for all nonpoint sources were provided by MARAMA for the following states: CT, DE, DC, ME, MD, MA, NH, NJ, NY, NC, PA, RI, VT, VA, and WV. During the development of 2016v2, some of these MARAMA factors were found to increase emissions by extremely large amounts (e.g., over 100 times). These erroneous factors were backed out of the 2016v2 inventories. The largest projections rolled back were for municipal waste combustors (MWC).

New Jersey provided their own projection factors for projection from 2014 to 2016 which were mostly the same as those provided by MARAMA, except for three SCCs with differences (SCCs: 2302070005, 2401030000, 2401070000). For those three SCCs, the projection factors provided by New Jersey were used instead of the MARAMA factors.

Non-IPM Projection from 2014 to 2016 outside MARAMA region

In areas outside of the MARAMA states, historical census population, sometimes by county and sometimes by state, was used to project select nonpt sources from the 2014NEIv2 to 2016v1 platform. The population data was downloaded from the US Census Bureau. Specifically, the "Population, Population Change, and Estimated Components of Population Change: April 1, 2010 to July 1, 2017" file (https://www2.census.gov/programs-surveys/popest/datasets/2010-2017/counties/totals/co-est2017-alldata.csv). A ratio of 2016 population to 2014 population was used to create a growth factor that was applied to the 2014NEIv2 emissions with SCCs matching the population-based SCCs listed in Table 2-8 Positive growth factors (from increasing population) were not capped, but negative growth factors (from decreasing population) were flatlined for no growth.

Table 2-8. SCCs for Census-based growth from 2014 to 2016

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2302002100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Charbroiling	Conveyorized Charbroiling
2302002200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Charbroiling	Under-fired Charbroiling
2302003000	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Deep Fat Frying	Total
2302003100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Deep Fat Frying	Flat Griddle Frying
2302003200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Deep Fat 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

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
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	Total
2810060100	Miscellaneous Area Sources	Other Combustion	Cremation	Humans

Other non-IPM updates incorporated when developing 2016v1

New Jersey, emissions for SCCs for Industrial (2102004000) and Commercial/Institutional (2103004000) Distillate Oil, Total: Boilers and Internal Combustion (IC) Engines were removed at that state's request. These emissions were derived from EPA estimates, and double counted emissions that were provided by New Jersey and assigned to other SCCs.

The state of New Jersey also requested that animal waste NH3 emissions from the following SCCs be removed: 2806010000 – Cats, 2806015000 – Dogs, 2807020001 – Black Bears, 2807020002 – Grizzly Bears, 2807025000 – Elk, 2807030000 – Deer, and 2810010000 – Human Perspiration and Respiration. These emissions existed in CA, DE, ME, NJ, and UT, and were removed from all states.

The state of Alaska reported several nonpoint sources that were missing in 2014NEIv2. Some of the sources reported by Alaska were identified in our EGU inventory and removed from the new nonpoint inventory. The rest of the stationary sources were converted to an FF10-formatted nonpoint inventory and included in 2016v1 platform in the nonpt sector.

The state of Alabama requested that their Industrial, Commercial, Institutional (ICI) Wood emissions (2102008000), which totaled more than 32,000 tons/year of PM2.5 emissions in the beta version of this emissions modeling platform and were significantly higher than other states' ICI Wood emissions, be removed from 2016v1 platform.

The state of New York provided a new set of non-residential wood combustion emissions for inclusion in 2016v1 platform. These new combustion emissions replace the emissions derived from the MARAMA projection.

The 2016fj case in the 2016v2 platform includes updates to a few specific ptnonipm units including the closure of the Guardian Corp facility (#2989611), which closed in 2015, and adjusted the emissions at AV RANCHOS WATER - WELL #4 to match those at WELL #9 because the emissions were determined to be unrealistically high.

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 2016 version 2 (v2) platform airport inventory is the airport emissions from the January 2021 version of the 2017 NEI. The SCCs included in the airport sector are shown in Table 2-9.

Table 2-9. 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, 2021). 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 is capped at 500% and the state default growth is 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.

2.2 2016 Nonpoint sources (afdust, fertilizer, livestock, np_oilgas, rwc, solvents, 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 2-10 is a listing of the Source Classification Codes (SCCs) in the afdust sector.

Table 2-10. 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

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
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
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

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
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
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

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
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
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 2016v2 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, 2021). The 2017 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. 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 in the 2016v2 inventory, including unpaved roads.

Area Fugitive Dust Transport Fraction

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 are shown in Table 2-11. 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.

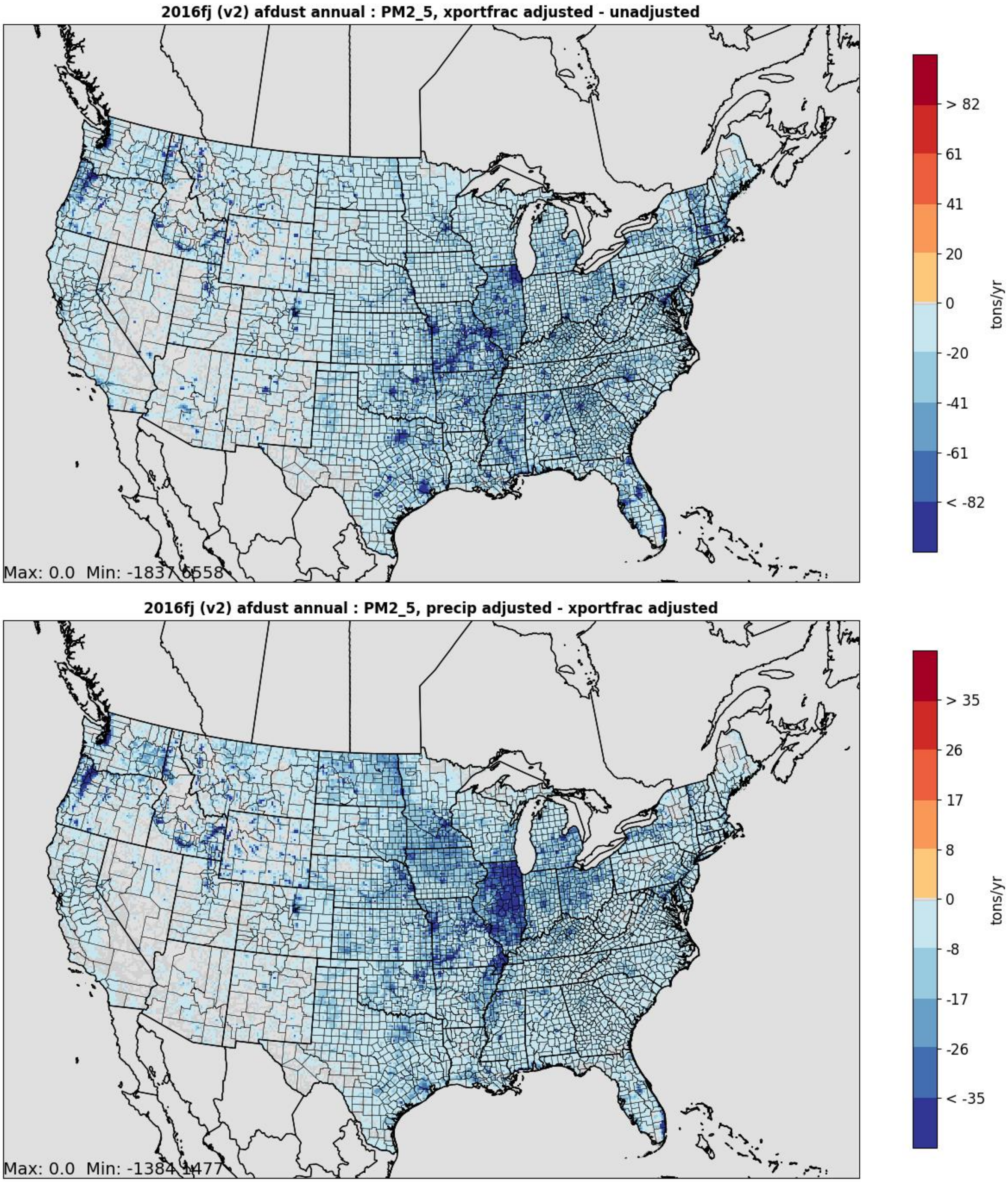
Table 2-11. Total impact of fugitive dust adjustments to unadjusted 2016v2 inventory

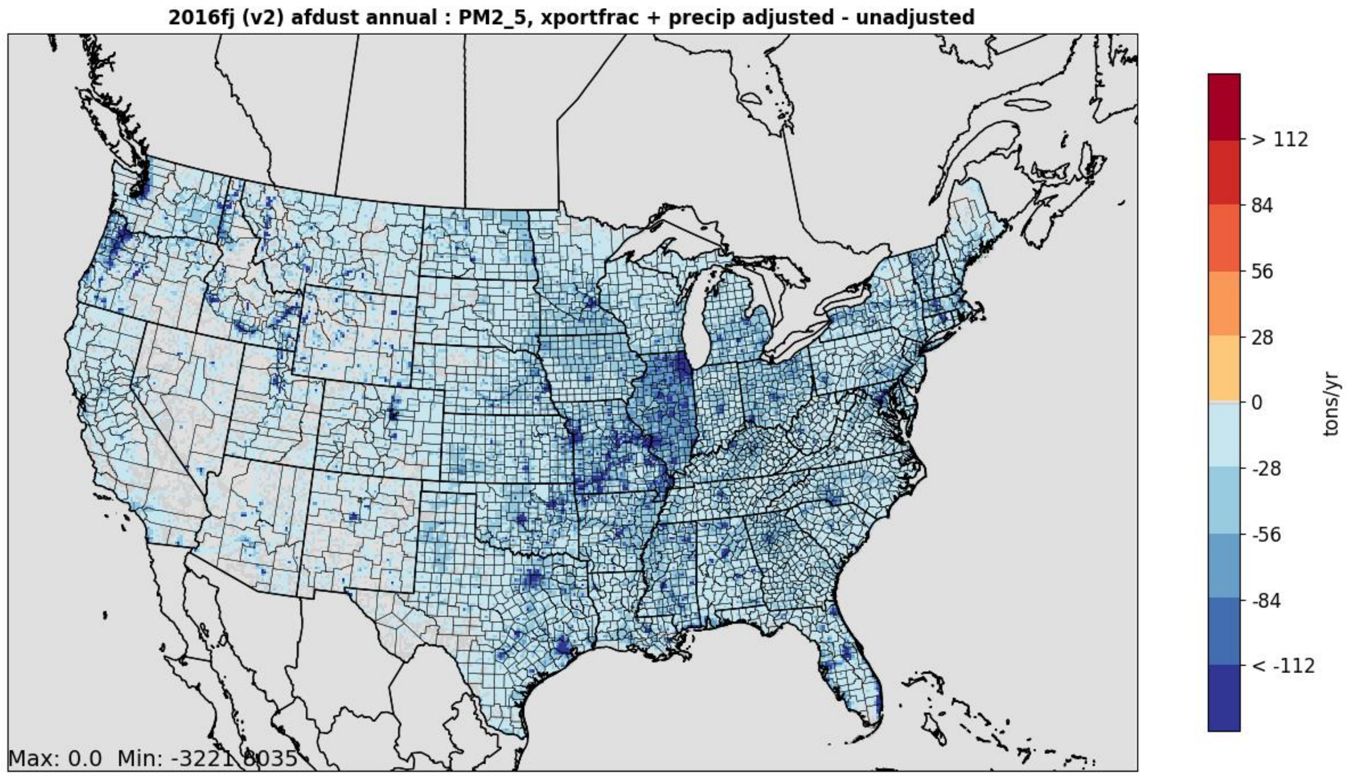
State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
Alabama	301,220	40,516	-206,837	-27,820	69%	69%
Arizona	180,413	24,148	-65,952	-8,640	37%	36%
Arkansas	389,426	53,870	-261,601	-35,627	67%	66%
California	307,525	38,907	-133,858	-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%

State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
New York	238,564	33,653	-178,529	-25,035	75%	74%
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	11,562	-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 uses a 2016 USDA-based county-level back-projection of 2017NEI livestock emissions. The SCCs included in the ag sector are shown in Table 2-12.

Table 2-12. 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 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, 2021). 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.

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 2-13. 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 (https://www.ers.usda.gov/webdocs/outlooks/87459/oce-2018-1.pdf?v=7587.1).

Table 2-13. 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

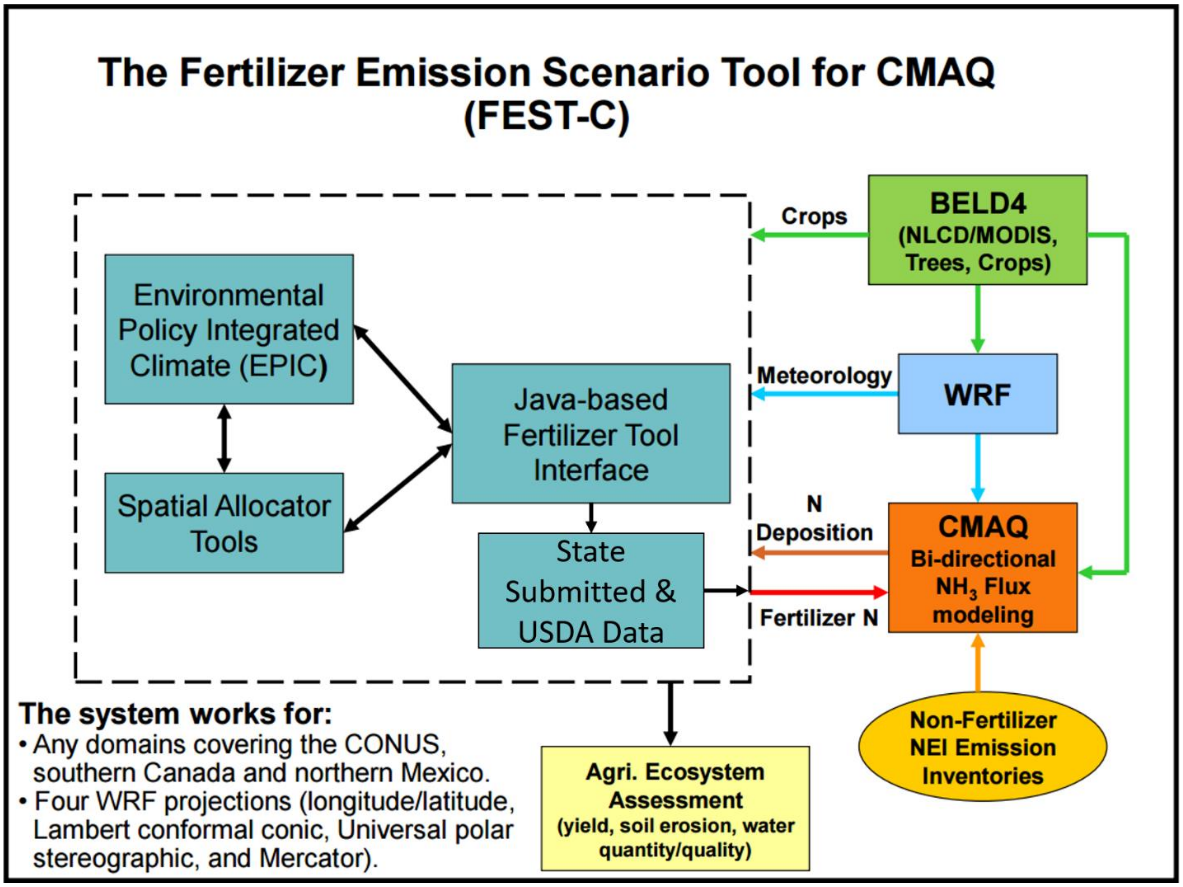
Area Sources; Ag. Production – Crops; Fertilizer Application; Miscellaneous Fertilizers). The bidirectional version of CMAQ (v5.3.2) and the Fertilizer Emissions Scenario Tool for CMAQ FEST-C (v1.4) were used to estimate ammonia (NH_3) emissions from agricultural soils. The approach to estimate year-specific 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 2-14 were used as EPIC model inputs.

Table 2-14. 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 Sector (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). In the 2016v1 platform, these emissions are mostly based on the EPA Oil and Gas Tool run with data specific to the year 2016, with some states submitting their own inventory data. 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 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. The 2016v1 of the nonpoint oil and gas emissions were mainly generated using the 2014 NEI version of the Oil and Gas Tool. 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 and 2016v2 platforms.

In Pennsylvania for the 2016v2 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.

Oklahoma Department of Environmental Quality requested that np_oilgas emissions from 2014NEIv2 be projected to 2016 for all source except lateral compressors. Projection factors for Oklahoma np_oilgas production, based on historical production data, are listed in Table 2-15. For lateral compressor emissions in Oklahoma, the EPA Oil and Gas Tool inventory for 2016 was used, except with a 72% cut applied to all emissions. Exploration np_oilgas emissions in Oklahoma are based on the EPA Oil and Gas Tool inventory for 2016, without modification.

Table 2-15. 2014NEIv2-to-2016 oil and gas projection factors for OK.

State/region	Emissions type	Factor	Pollutant(s)
Oklahoma	Oil Production	+6.9%	All
Oklahoma	Natural Gas Production	+5.9%	All
Oklahoma	Combination Oil + NG Production	+6.4%	All
Oklahoma	Coal Bed Methane Production	-30.0%	All

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 2-16.

Table 2-16. 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
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, chimineas, etc)
2104009000	Stationary Source Fuel Combustion	Residential	Firelog	Total: All Combustor Types

For all states, RWC emissions from the 2017NEI were backcast to 2016 using a single projection factor (+3.254%) based on data from EIA/SEDS.

2.2.6 Solvents (solvents)

The 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 platform, these products comprise the solvents sector.

The types of sources in the solvents sector include, but are not limited to:

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

For the 2016v2 platform, emissions from the solvent 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 where the aforementioned datasets were 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). For oil and gas solvent usage, the composition is assumed to be dominated by methanol and other hydrocarbon blends. 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, 2021). Agricultural pesticides are allocated using county-level agricultural pesticide use, as taken from the 2017 NEI and oil and gas emissions are allocated using oil and gas well counts (U.S. EIA, 2019).

For 2016v2, point and nonpoint emissions with SCCs that overlap the solvents sector were removed from the ptnonipm and nonpt sectors.

2.2.7 Nonpoint (nonpt)

The starting points for the 2016v2 nonpt inventory are the 2017 NEI and the 2014 NEI, including all nonpoint sources that are not included in the sectors afdust, ag, cmv_c1c2, cmv_c3, np_oilgas, rail, rwc, or solvents. The types of sources in the nonpt sector taken from 2016v1 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; and
- cellulosic biorefining.

For 2016v2, emissions were taken from 2017 NEI for waste disposal (including composting), miscellaneous non-industrial sources such as cremation, hospitals, lamp breakage, and automotive repair shops; bulk gasoline terminals; portable gas cans; and any construction agricultural dust or waste that is not part of the afdust or livestock sectors. For biomass fuel combustion, 2017 NEI data were backcast to 2016 by applying a 4.27% reduction for industrial emissions, 0.15% reduction for commercial emissions. Refueling emissions at gas stations that are in the nonpt sector were interpolated to 2016 between 2002 and 2017 levels. Other nonpt emissions are the same as those in the 2016v1 platform, except for solvents that were moved to the solvents sector.

Adjustment of nonpt sources to 2016

Census population, sometimes by county and sometimes by state, was used to backcast select nonpt sources from the 2017 NEI to 2016. The population data was downloaded from the US Census Bureau. Specifically, the "Population, Population Change, and Estimated Components of Population Change: April 1, 2010 to July 1, 2017" file (https://www2.census.gov/programs-surveys/popest/datasets/2010-2017/counties/totals/co-est2017-alldata.csv). A ratio of 2016 population to 2014 population was used to create a growth factor that was applied to the 2014NEIv2 emissions with SCCs matching the population-based SCCs listed in Table 2-17. Positive growth factors (from increasing population) were not capped, but negative growth factors (from decreasing population) were flatlined for no growth.

Table 2-17. SCCs receiving Census-based adjustments to 2016

SCC	Tier 1 Description	Tier 2 Description	Tier 3 Description	Tier 4 Description
2302002100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Charbroiling	Conveyorized Charbroiling
2302002200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Charbroiling	Under-fired Charbroiling
2302003000	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Deep Fat Frying	Total
2302003100	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Deep Fat Frying	Flat Griddle Frying
2302003200	Industrial Processes	Food and Kindred Products: SIC 20	Commercial Deep Fat Frying	Clamshell Griddle Frying

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 idle) 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 model platform also distinguish between emissions processes (i.e., off-network, on-network, and extended idle), and road types.

Onroad emissions were computed with SMOKE-MOVES by multiplying specific types of vehicle activity data by the appropriate emission factors. 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 2-18. 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. Emissions 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.

Table 2-18. 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 platform are shown in Table 2-19. Note that Florida and Rhode Island activity data were projected from 2014 to 2016.

Table 2-19. 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	
Delaware			yes
District of Columbia			yes
Georgia	yes	yes	
Idaho			yes
Illinois - Chicago area	yes	yes	
Illinois - rest of state	yes	yes	

Agency	2016 VMT	2016 VPOP	2017 NEI
Indiana - Louisville area	yes		
Kentucky - Jefferson	yes	yes	yes
Kentucky - Louisville exurbs	yes		
Maine			yes
Maryland	yes	yes	yes
Massachusetts	yes	yes	
Michigan - Detroit area	yes	yes	
Michigan - rest of state	yes	yes	
Minnesota	yes	yes	
Missouri			yes
Nevada - Clark	yes	yes	yes
Nevada - Washoe			yes
New Hampshire	yes	yes	
New Jersey	yes	yes	
New York			yes
North Carolina	yes	yes	
Ohio			yes
Pennsylvania	yes	yes	
South Carolina	yes	yes	
Tennessee - Davidson			yes
Tennessee - Knox			yes
Texas			yes
Vermont			yes
Virginia	yes	yes	
Washington			yes
West Virginia	yes	yes	
Wisconsin	yes	yes	

Vehicle Miles Traveled (VMT)

EPA calculated default 2016 VMT by backcasting the 2017 NEI VMT to 2016. The 2017 NEI Technical Support Document has details on the development of the 2017 VMT (EPA, 2021). The data backcast to 2016 were used for states that did not submit 2016 VMT data. 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 factors based on FHWA VM-2 County data for 2017 and 2016. Separate factors were calculated by vehicle type for each of the 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. 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, 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 2016v2 VMT data for all states are provided in Table 2-20.

Table 2-20. State total differences between 2017 NEI and 2016v2 VMT data

State	2017 NEI-2016v2 %	State	2017 NEI-2016v2 %
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 platform, 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 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, 2021b). 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 resplit 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).

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.

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 we used 2016v1 VMT resplit to MOVES3 fuels, 2016v2 VPOP = 2016v1 VPOP with two resplits: First, source types 21/31/32 were resplit according to 2017 NEI EPA default 21/31/32 splits so that the whole country has consistent 21/31/32 splits. Next, fuels were resplit to MOVES3 fuels. There are some areas where 2016 VMT was submitted but 2016 VPOP was not; those areas are using 2016v1 VPOP (with resplits). The same method was applied to the 2016 EPA default VMT to produce an EPA default VPOP data set.

Hoteling Hours (HOTELING)

Hoteling hours activity is used to calculate emissions from extended idling and auxiliary power units (APUs) for heavy duty diesel vehicles. Many states have commented that EPA estimates of hoteling hours, and therefore emissions resulting from hoteling, are higher than they could realistically be in reality given the available parking spaces. Therefore, recent hoteling activity datasets, including the 2014NEIv2, 2016 beta, and 2016v1 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 in 2016v2 is the following:

1. Start with 2016 VMT for source type 62 on restricted roads, by county.
2. 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.)
3. 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, we started with the hoteling hours for the county as computed by the above method, and then we applied reductions directly 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.

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.

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 89%, 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)

Georgia and New Jersey submitted hoteling activity for the 2016v1 platform, which was carried through to v2 with an updated APU factor for MOVES3 2016. For these states, the EPA default projection was 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 first needed to be converted to annual totals by county.

Alaska Department of Natural Resources staff requested that we zero out hoteling activity in several counties due to the nature of driving patterns in their region. In addition, 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 did not apply any reductions based on parking space availability and left the hours that were computed using the updated method for 2016v1; or in the case of New Jersey, their submitted activity data were unchanged.

Finally, the county total hoteling must be 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 - we backcast 2017 hoteling to 2016 using the FHWA-based county total 2017 to 2016 trend. Finally, the annual parking-space-based caps for hoteling hours were applied. The same caps were used as for 2017NEI, except recalculated for a leap year (multiplied by 366/365).

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.

2016v2 STARTS = 2016v2 VMT * (2017 STARTS/ 2017 VMT by county&SCC6)

Off-network Idling Hours

After creating VMT inputs for SMOKE-MOVES, Off-network idle (ONI) activity data were also needed. ONI is defined in MOVES as time during which a vehicle engine is running idle and the vehicle is somewhere other than on the road, 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 ONI activity 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 the road, 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.

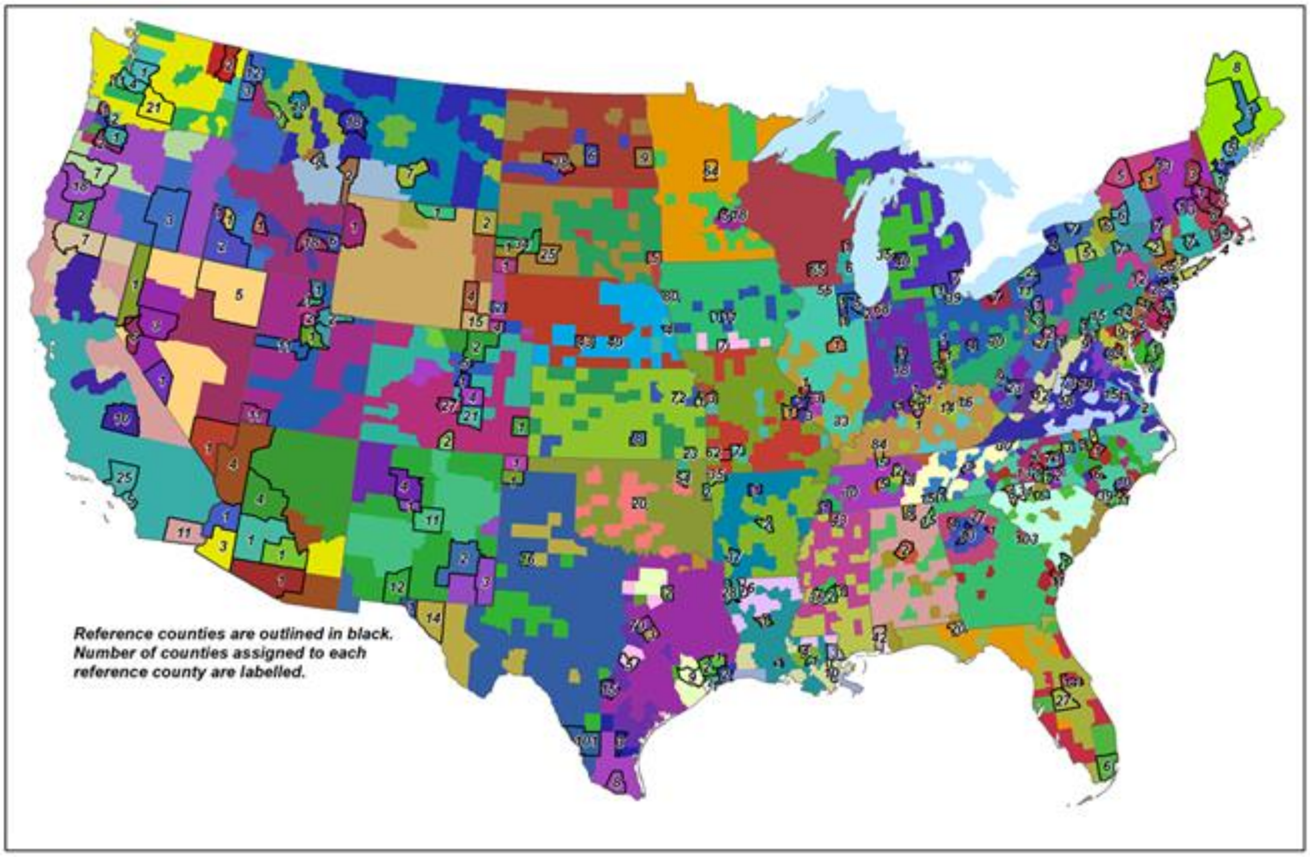
ONI activity hours were calculated based on VMT. For each representative county, the ratio of ONI hours to onroad VMT (on all road types) was calculated using the MOVES ONI Tool by source type, fuel type, and month. These ratios are then multiplied by each county's total VMT (aggregated by source type, fuel type, and month) to get hours of ONI activity.

2.3.2 MOVES Emission Factor Table Development

MOVES3 was run in emission rate mode to create emission factor tables using CB6 speciation for the years 2016, 2023, 2026, and 2032, for all representative counties and fuel months. MOVES was run for all counties in Alaska, Hawaii, and Virgin Islands, and for a single representative county in Puerto Rico.

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[2]. 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.

Figure 2-3. Representative Counties in 2016v2



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_addFY23-26-32Parameters.xlsx" (ERG, 2021).

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. The 2016 years were then grown to each future year 2023, 2026, and 2032 everywhere except Alaska. Alaska age distributions were not changed in the future 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

[2] 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.

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 is 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.

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 age 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 (back to 2013) data pull dates, so were 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 source type 21 and light trucks to match 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 as one minus the fraction of vehicles to remove from IHS to equal the state data, with two exceptions: (1) the model year range 2006/2007 to 2017 receives no adjustment and (2) the model year 1987 receives a capped adjustment that equals the adjustment to 1988. Table 2-21 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 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 as high as 6 percent in some states (e.g., Mississippi).

Table 2-21. 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

Model Year	Cars	Light
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 Bus and Refuse Truck 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.

To create the emission factors, MOVES3 was run separately for each representative county and fuel month and for each temperature bin needed for calendar year 2016. The CDBs used to run MOVES include the state-specific control measures such as the California low emission vehicle (LEV) program, except that 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, but do not include NH3 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:

1) CARB refueling was backcast from 2017NEI to 2016 using MOVES trends, and then SMOKE-MOVES was adjusted to match the backcast refueling.
2) California NH3 was set to MOVES state total NH3, distributed to county-SCC following the distribution of carbon monoxide (CO) as a surrogate for activity.
3) For vehicle types other than 62 where CARB provided “idling” emissions, those emissions were mapped to ONI. For vehicle 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).

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 2016v2 CMV emissions are based on the emissions developed for the 2017 NEI and are the same as those used in the 2016v1 platform. 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.

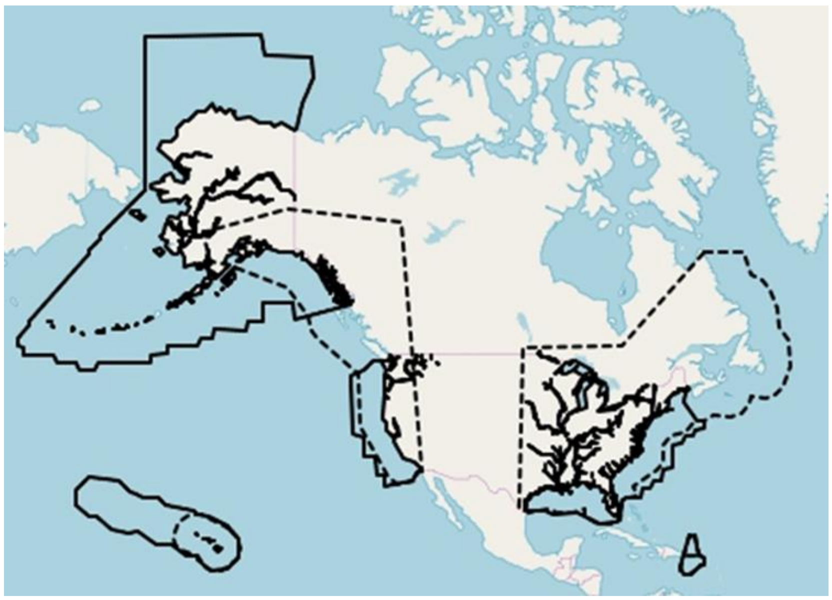
The cmv_c1c2 sources within state waters are identified in the inventory with the Federal Information Processing Standard (FIPS) county code for the state and county in which the vessel is registered. The cmv_c1c2 sources that operate outside of state waters but within the Emissions Control Area (ECA) 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 2-22.

Table 2-22. 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,[3] 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.

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. 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

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

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.

$$Emissions_{interval} = Time\ (hr)_{interval} \times\ Power(kW) \times EF(\frac{g}{kWh}) \times LLAF$$ **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 2-23. 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 2-23. 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 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. 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 2-22.

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.[4] 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[5] 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

[4] 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.

[5] 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.

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 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 fuel used by these vessels.[6] 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 2-24. 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.[7] 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 2-24. 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

[6] https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-marine-vessels.
[7] https://www.epa.gov/sites/production/files/2017-08/documents/2014v7.0_2014_emismod_tsdv1.pdf.

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.[8] 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. 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 USGS 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.

$$Emissions_{interval} = Time\ (hr)_{interval} \times\ Power(kW) \times EF(\frac{g}{kWh}) \times LLAF$$ **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.

[8] 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.

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,[9] 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.

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 Environment Canada and the 2011 ECA-IMO C3 inventory.

For the gap-filled areas not covered by AIS selections or the Environment Canada inventory, the 2016 nonpoint C3 inventory 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

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

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 2-25. 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 2-25. 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] Above ratios were applied to the 2017 emission values to estimate 2016 values

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. The rail sector includes all locomotives in the NEI nonpoint data category. The 2016v1 inventory SCCs are shown in Table 2-26. 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 point inventory / ptnonipm sector. Therefore, SCC 2285002010 is not present in the 2016v1 platform rail sector, except in three California counties. 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 2-26. 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 2-27), 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 2-27. 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)

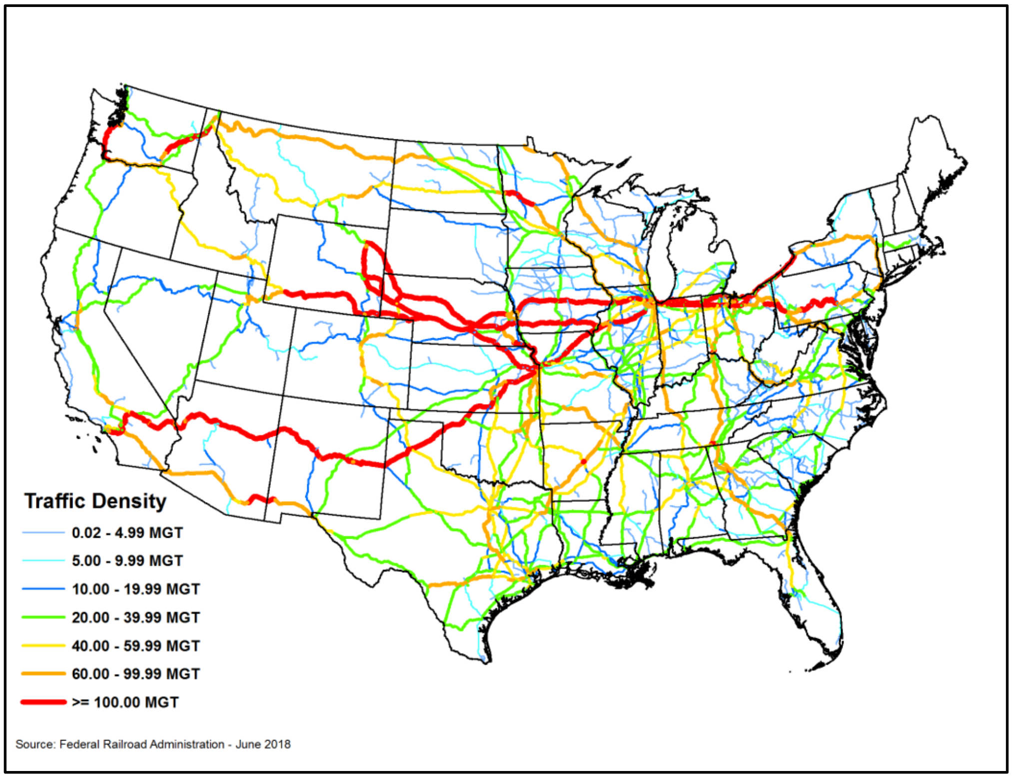
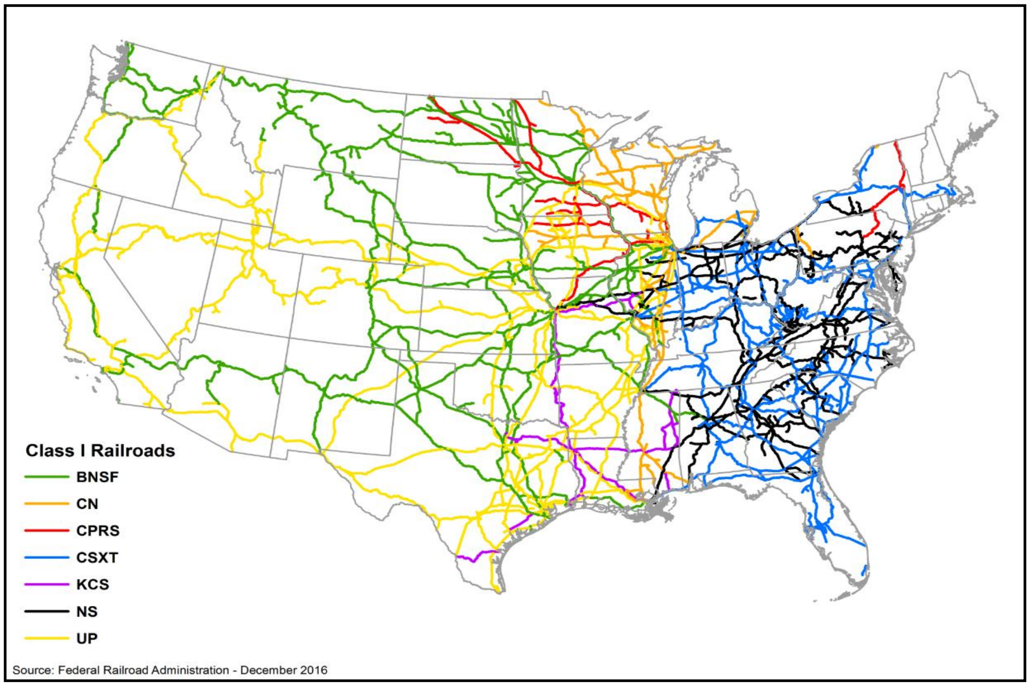


Figure 2-6. Class I Railroads in the United States[5]



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 2-28.

Table 2-28. 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).

$$EF_i = \sum_{T=1}^{9} EF_{iT} \times f_T \quad \text{Equation 2-3}$$

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 1 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 2-29 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 2-30.

Table 2-29. 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**

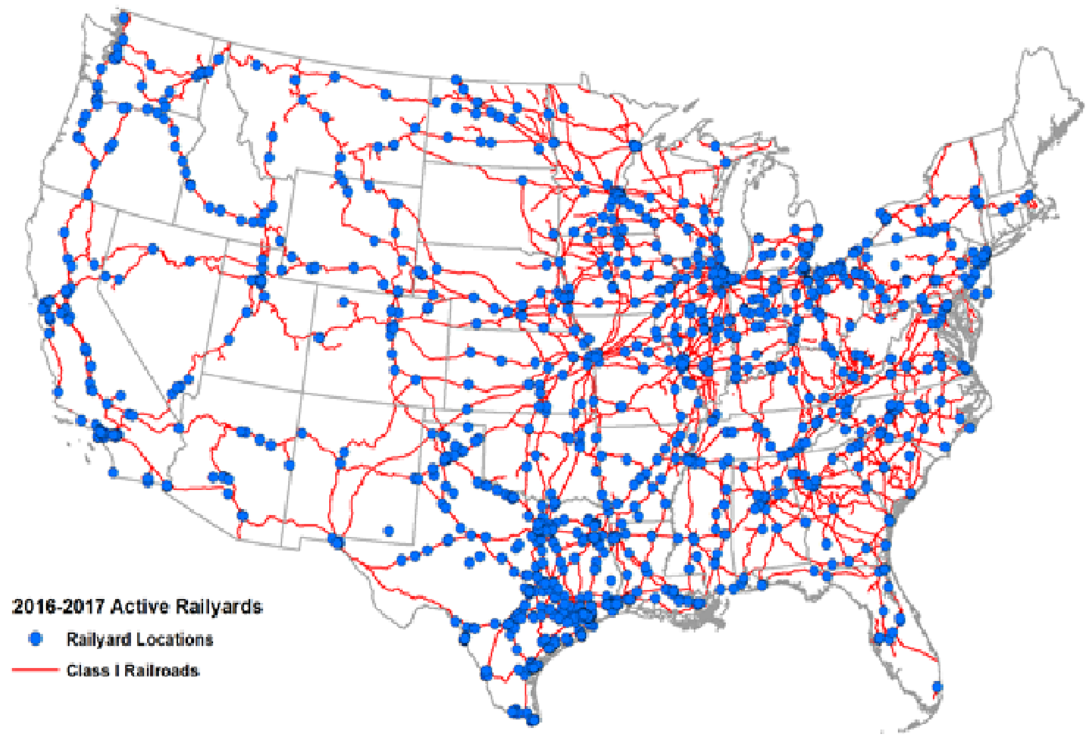
Table 2-30. 2016 Yard Switcher Emission Factors by Tier, AAR Fleet Mix (grams/gal)[4]

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



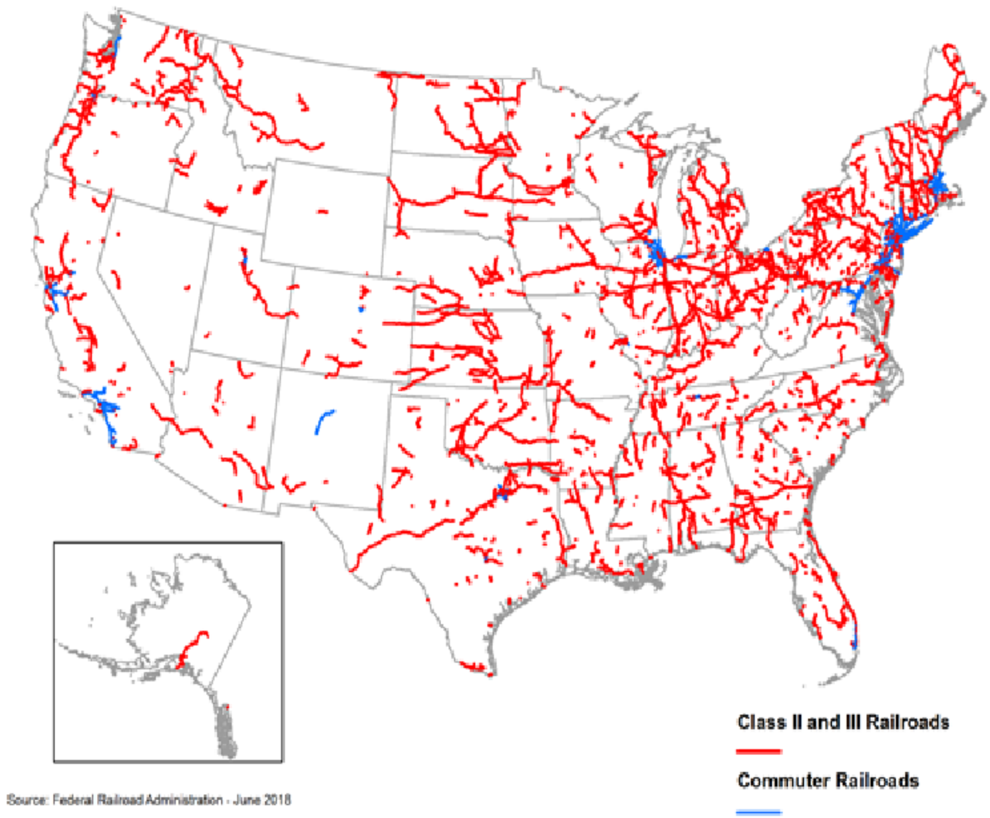
Source: Federal Railroad Administration

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 future development of a more accurate nationwide short line and regional railroad emissions inventory. A picture of the locations of class II and III railroads is shown in Figure 2-8. 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 2-31 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 2-31. 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

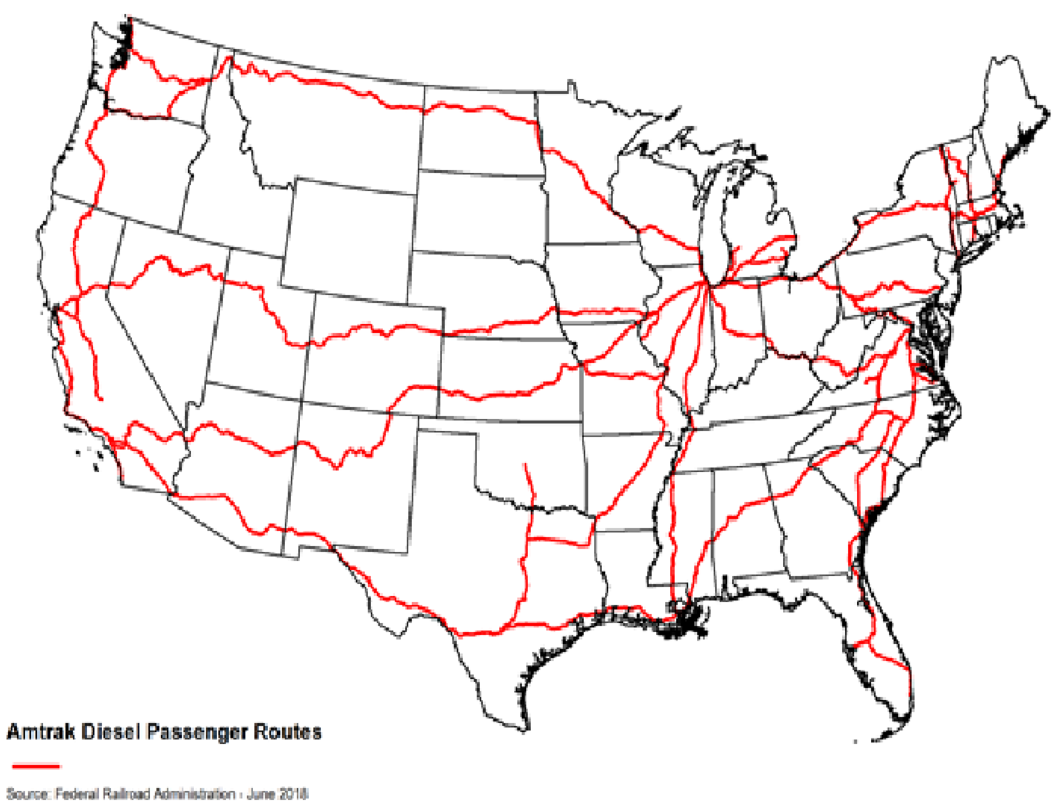
FRA Code	System	Cities Served	Propulsion Type	DOT Fuel & Lube Costs	Reported/Estimated Fuel Use
DRTD	Denver RTD: A&B Lines	Denver	Electric	$0	0.00
JPBX	Caltrain	San Francisco / San Jose	Diesel	$7,002,612	3,446,881.55
LI	MTA Long Island Rail Road	New York	Electric and Diesel	$13,072,158	6,434,481.92
MARC	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,[10] 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.

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.

10 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 platform.

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.”[11] 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.

[11] 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).[12] 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).[13] 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.[14]

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.[15] 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

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

function.[16] The 2017 NEI Technical Support Document (EPA, 2021) 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: ftp://newftp.epa.gov/air/emismod/2016/v1/reports/nonroad/ or at https://gaftp.epa.gov/air/emismod/2016/v1/reports/nonroad/).

State-Supplied Nonroad Data

As shown Table 2-32. several state and local agencies provided nonroad inputs for use in the 2016v1 platform that were carried forward into the 2016v2 platform. 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 is therefore not shown in this table.

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

Table 2-32. 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.[17] 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 2-33).

Table 2-33. Alaska counties/census areas for which nonroad equipment sector-specific emissions are removed in 2016v1 and 2016v2

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 (02195), Pr of Wales-Hyder Census Area (02198), Sitka

[17] For more information on the TexN2 tool please see: ftp://amdaftp.tceq.texas.gov/EI/nonroad/TexN2/.

Nonroad Equipment Sector	Counties/Census Areas (FIPS) for which equipment sector emissions are removed in 2016
	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). The wildfires and prescribed fires were broken up into two different sectors, ptfire-wild and ptfire-rx respectively, for 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 2-34. 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 2-34.

Table 2-34. SCCs included in the ptfire sector for the 2016v2 inventory

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 2-35 provides the national fire information databases that were used for the 2016v1 ptfire inventory, including the website where the 2016 data were downloaded.

Table 2-35. National fire information databases used in 2016v1 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://www.geomac.gov/GeoMACTransition.shtml
Incident Command System Form 209: Incident Status Summary (ICS-209)	WF/RX	CSV	Multi	Entire US	https://fam.nwcg.gov/fam-web/
National Association of State Foresters (NASF)	WF	CSV	Multi	Participating US states	https://fam.nwcg.gov/fam-web/ (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

Dataset Name	Fire Types	Format	Agency	Coverage	Source
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 2-36. Data from nine individual states and one Indian Tribe were used for the 2016v1 ptfire inventory.

Table 2-36. 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
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 2-37 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 2-37. 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 2-34. The lofted smoldering emissions were assigned to the flaming emissions SCCs in Table 2-34.

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 2016v1 inventory

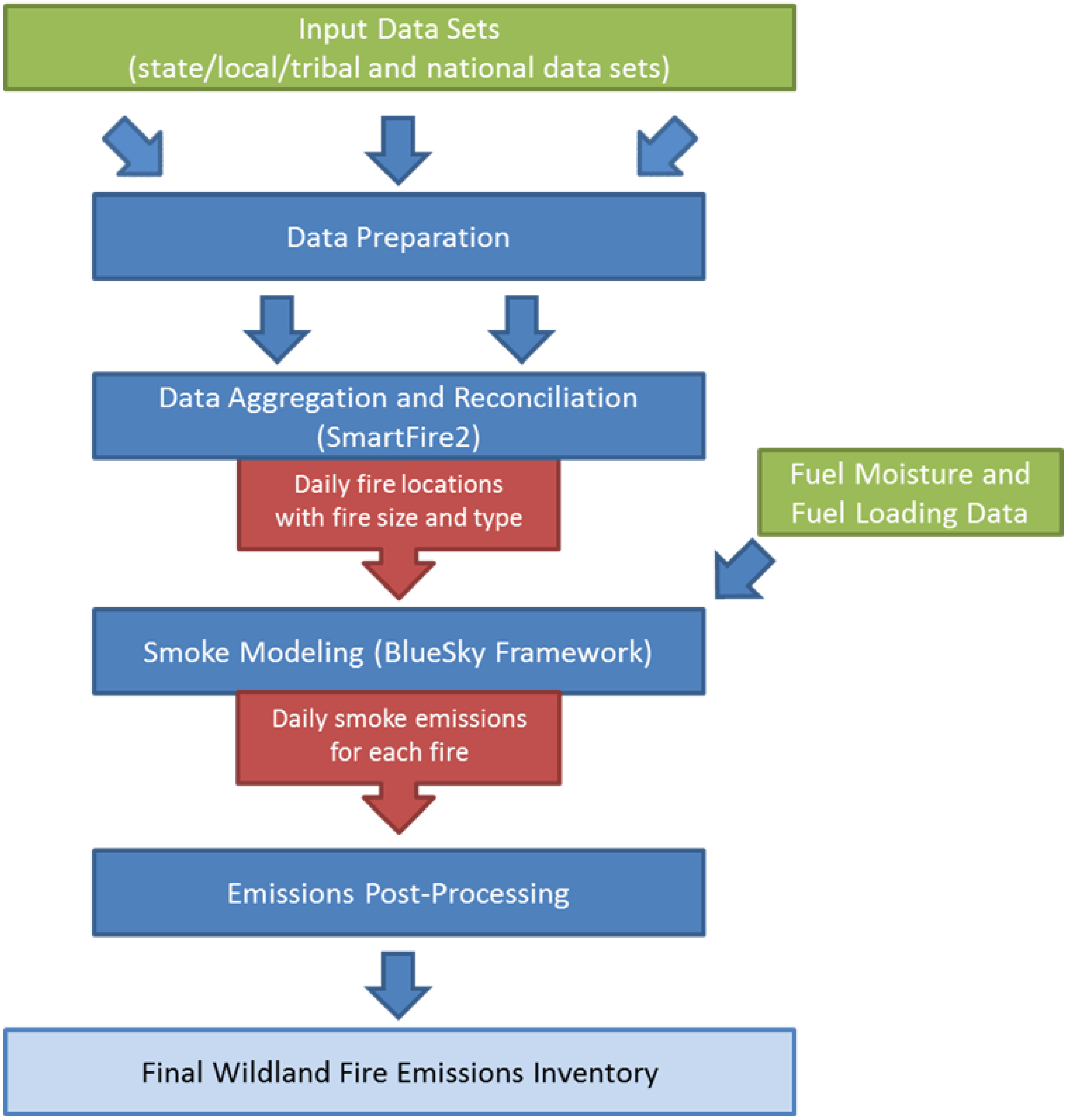
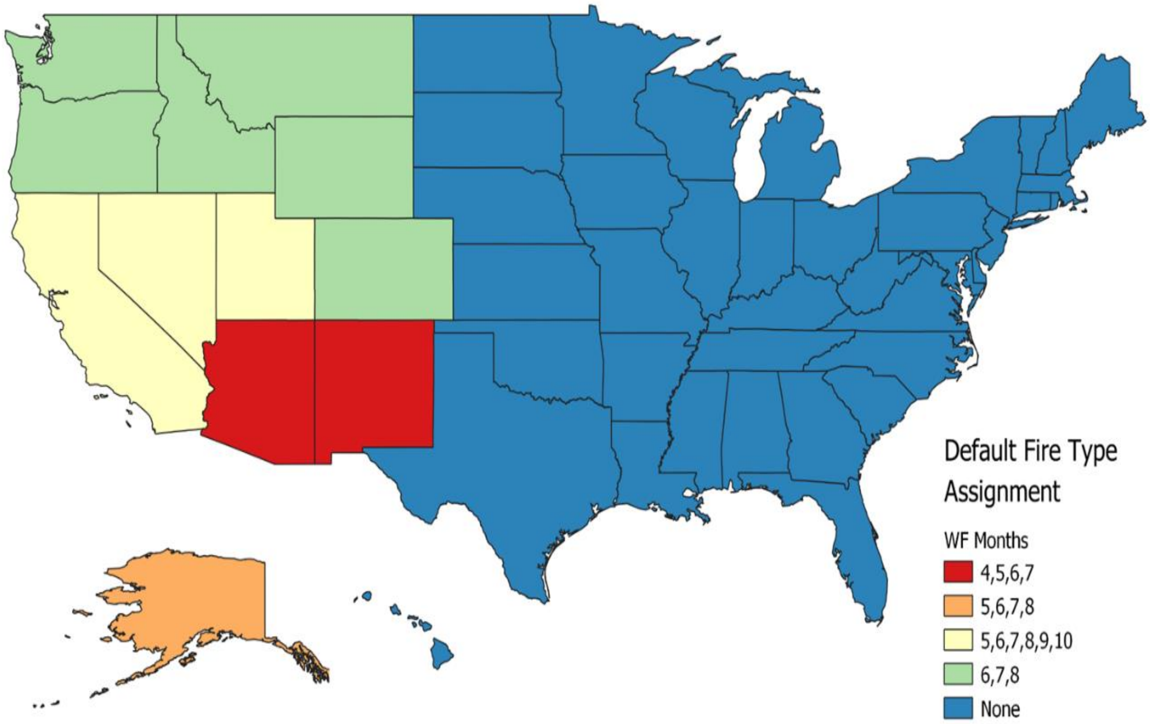
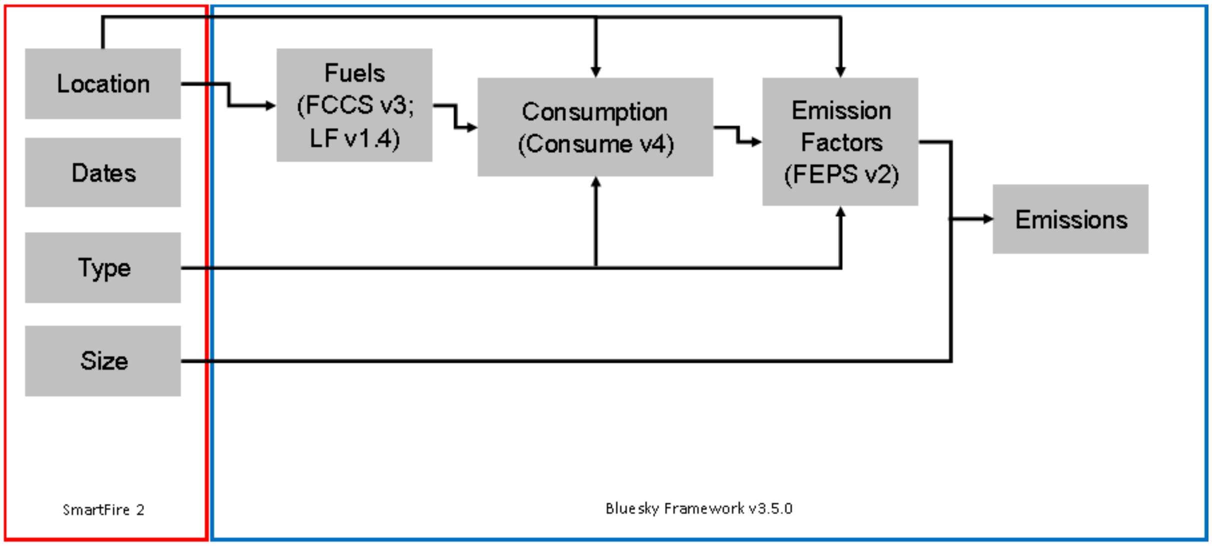


Figure 2-11. Default fire type assignment by state and month where data are only from satellites.



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).

Figure 2-12. BlueSky Modeling Framework



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 was required to allow these data to work in the BlueSky 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 2-38.

Table 2-38. SCCs included in the ptagfire sector for the 2016v1 inventory

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

SCC	Description
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
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 2-39.

Table 2-39. 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 the entire year 2016 were developed using the Biogenic Emission Inventory System version 3.7 (BEIS3.7) within SMOKE. The landuse input into BEIS3.7 is the Biogenic Emissions Landuse Dataset (BELD) version 5.

The BELD5 includes the following datasets:

- Newer version of the Forest Inventory and Analysis (FIA version 8.0 https://www.fia.fs.fed.us/library/database-documentation/index.php)
- Agricultural land use from the 2017 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)
    - Note BELD4.1 used 2011 USGS National Land Cover Data (NLCD) limited to the USA and MODIS 20 category land use for the rest of the world.
- Canadian BELD land use (https://www.epa.gov/sites/default/files/2019-08/documents/800am_zhang_2_0.pdf).

The FIA database reports on status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership. The FIA database version 8.0 includes recent updates of these data through the year 2017 (from 2001). Earlier versions of BELD used an older version of the FIA database that had included data only through the year 2014. Canopy coverage is based on the MODIS 20 category data. The FIA includes approximately 250,000 representative plots of species fraction data that are within approximately 75 km of one another in areas identified as forest by the MODIS canopy coverage. For all land areas in the United States, 500-meter grid spacing land cover data from the MODIS is used.

The processing of the BELD5 data follows the spatial allocation methods of Bash et al. 2016 like BELD 4. However, MODIS land use categories and FPAR are used in the place of NLCD land use and forest coverage. MODIS land use has the additional broadleaf evergreen and deciduous needleleaf land use types and only one developed land use type. BELD4.1 used lookup tables for species leaf biomass. In BELD5, allometric relationships from the FIA v8.0 database (https://www.fia.fs.fed.us/library/database-documentation/index.php) were utilized to estimate foliage biomass per species. This resulted in better agreement with measured foliage biomass. BVOC emissions are understood to originate from foliage thus these biomass changes directly impacted the BEIS emission factors.

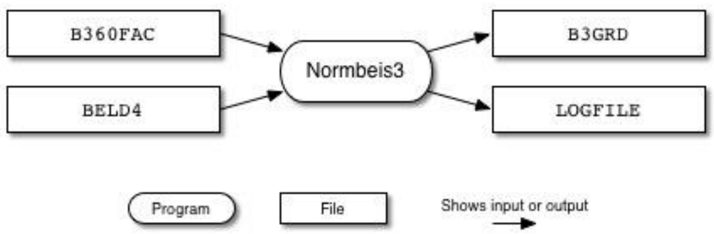
BEIS3.7 has some important updates from BEIS 3.61. These include the incorporation of Version 5 of the Biogenic Emissions Landuse Database (BELD5), and updates to biomass emissions factors. The biomass emissions factor updates take into account FIA updates. BEIS3.7 includes a two-layer canopy model. 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 BEIS3.7 processing are shown in Table 2-40. The 2016 BEIS3 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 BEIS3 emissions dataset.

Table 2-40. Hourly Meteorological variables required by BEIS 3.7

Variable	Description
LAI	leaf-area index
PRSFC	surface pressure
Q2	mixing ratio at 2 m
RC	convective precipitation
RGRND	solar radiation reaching surface
RN	nonconvective precipitation
RSTOMI	inverse of bulk stomatal resistance
SLYTP	soil texture type by USDA category
SOIM1	volumetric soil moisture in top cm
SOIT1	soil temperature in top cm
TEMPG	skin temperature at ground
USTAR	cell averaged friction velocity
RADYNI	inverse of aerodynamic resistance
TEMP2	temperature at 2 m

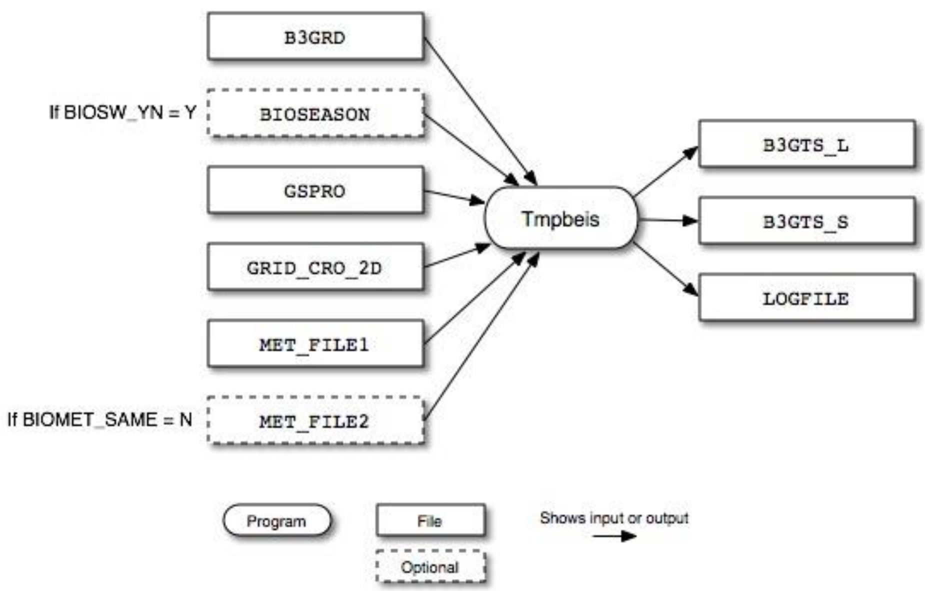
SMOKE-BEIS3 modeling system consists of two programs named: 1) Normbeis3 and 2) Tmpbeis3. Normbeis3 uses emissions factors and BELD5 landuse to compute gridded normalized emissions for chosen model domain (see Figure 2-13). The emissions factor file (B360FAC) contains leaf-area-indices (LAI), dry leaf biomass, winter biomass factor, indicator of specific leaf weight, and normalized emission fluxes for 35 different species/compounds. The BELD5 file is the gridded landuse for many different landuse types. The output gridded domain is the same as the input domain for the land use data. Output emission fluxes (B3GRD) are normalized to 30 °C, and isoprene and methyl-butenol fluxes are also normalized to a photosynthetic active radiation of 1000 μmol/m^{2}s.

Figure 2-13. Normbeis3 data flows



The normalized emissions output from Normbeis3 (B3GRD) are input into Tmpbeis3 along with the MCIP meteorological data, chemical speciation profile to use for desired chemical mechanism, and BIOSEASON file used to indicate how each day in year 2016 should be treated, either as summer or winter. Figure 2-14 illustrates the data flows for the Tmpbeis3 program. The output from Tmpbeis includes gridded, speciated, hourly emissions both in moles/second (B3GTS_L) and tons/hour (B3GTS_S).

Figure 2-14. Tmpbeis3 data flow diagram.



Biogenic emissions do not use an emissions inventory and do not have SCCs. The gridded land use data, gridded meteorology, an emissions factor file, and a speciation profile are further described in the next section.

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. Emissions for Mexico are based on the Inventario Nacional de Emisiones de Mexico, 2008 projected to year 2016 (ERG, 2014a). Additional details for these sectors can be found in the 2016v1 platform specification sheets.

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. A new 2016 inventory was also provided by SEMARNAT of Mexico. Due to the large number of points in the Canada inventories, 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, many 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.

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, new year 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.

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 the 2016v1 inventories were used. The Mexico onroad emissions are based on MOVES-Mexico runs for 2014 and 2018 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 Environment Canada when available. Environment Canada 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. These 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 and Sea Salt

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.

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 seen 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.

3.1 Emissions modeling Overview

SMOKE version 4.8.1 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 Tmpbeis3 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	in BEIS 3.7	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	
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	
onroad_can	Surrogates	Yes	monthly	
onroad_mex	Surrogates	Yes	monthly	
othafdust_adj	Surrogates	Yes	annual	

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
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	
solvents	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 2016v2 platform, 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.

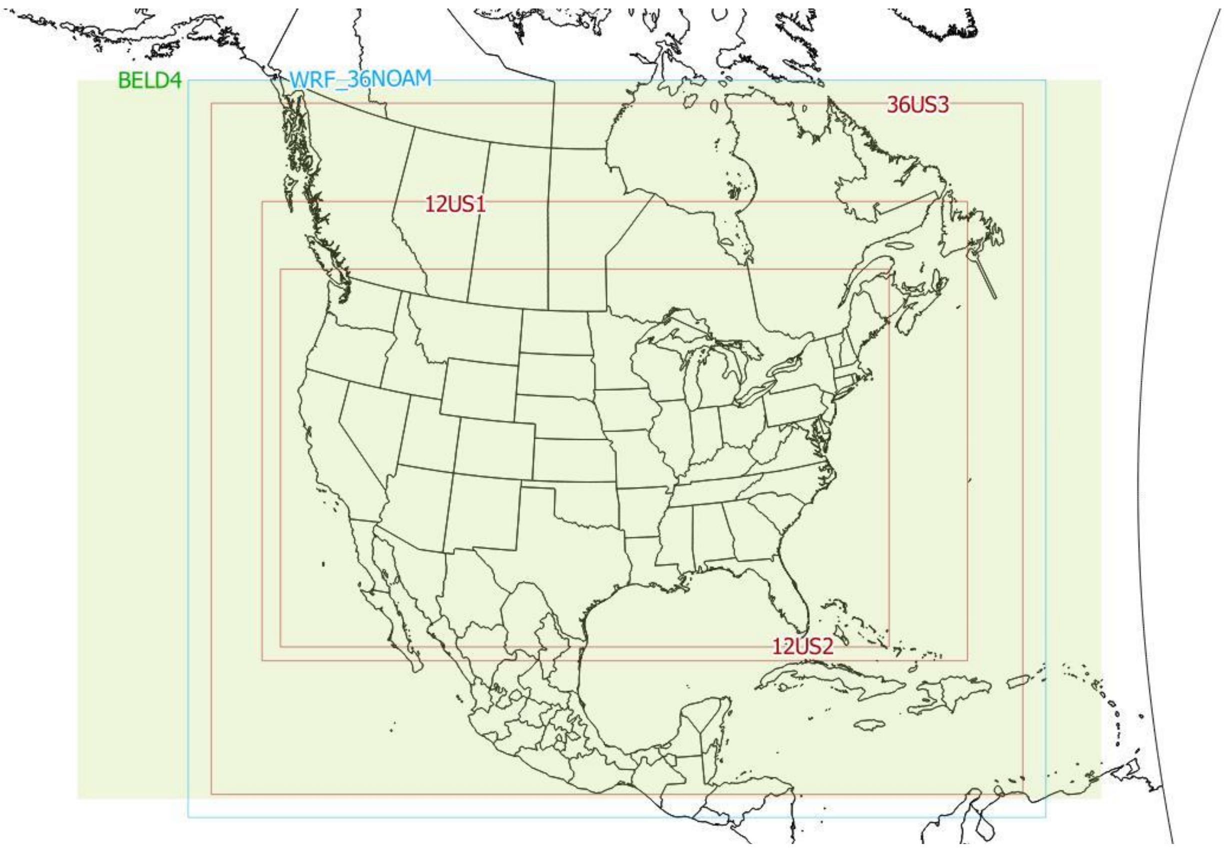
SMOKE has the option of grouping sources so that they are treated as a single stack when computing plume rise. For this platform, no grouping was performed because grouping combined with "in-line" processing will not give identical results as "offline" processing (i.e., when SMOKE creates 3-dimensional 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, 2026, and 2032. Emissions were developed for 36US3 for 2016 and 2023 only. The outputs of CAMx on 36US3 are used to create boundary conditions for the 12US2 domains. For 2026 and 2032, 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 the species added from compared to CB6 are 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 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).

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 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
	NO2	Nitrogen dioxide
	HONO	Nitrous acid
SO_2	SO2	Sulfur dioxide
	SULF	Sulfuric acid vapor
NH_3	NH3	Ammonia
	NH3_FERT	Ammonia from fertilizer
VOC	AACD	Acetic acid
	ACET	Acetone
	ALD2	Acetaldehyde
	ALDX	Propionaldehyde and higher aldehydes
	APIN	Alpha pinene
	BENZ	Benzene (not part of CB05)
	CH4	Methane
	ETH	Ethene
	ETHA	Ethane
	ETHY	Ethyne
	ETOH	Ethanol
	FACD	Formic acid
	FORM	Formaldehyde
	IOLE	Internal olefin carbon bond (R-C=C-R)
	ISOP	Isoprene
	IVOC	Intermediate volatility organic compounds

Inventory Pollutant	Model Species	Model species description
	KET	Ketone Groups
	MEOH	Methanol
	NAPH	Naphthalene
	NVOL	Non-volatile compounds
	OLE	Terminal olefin carbon bond (R-C=C)
	PAR	Paraffin carbon bond
	PRPA	Propane
	SESQ	Sequiterpenes (from biogenics only)
	SOAALK	Secondary Organic Aerosol (SOA) tracer
	TERP	Terpenes (from biogenics only)
	TOL	Toluene and other monoalkyl aromatics
	UNR	Unreactive
	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
	PNO3	Particulate nitrate ≤ 2.5 microns
	POC	Particulate organic carbon (carbon only) ≤ 2.5 microns
	PSO4	Particulate Sulfate ≤ 2.5 microns
	PAL	Aluminum
	PCA	Calcium
	PCL	Chloride
	PFE	Iron
	PK	Potassium
	PH2O	Water
	PMG	Magnesium
	PMN	Manganese
	PMOTHR	$PM_{2.5}$ not in other AE6 species
	PNA	Sodium
	PNCOM	Non-carbon organic matter
	PNH4	Ammonium
	PSI	Silica
	PTI	Titanium

One additional species in the emissions files but not on 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 were developed from a draft version of 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.

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 Environment Canada (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 Environment Canada 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.

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

- New profiles were incorporated for solvents;
- 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 in 2016v2 included:

- solvents use the newly developed speciation profiles for that sector;
- 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 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;
- Added 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 4 representative states for forest fires and 2 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 of the species listed in Table 3-3, emissions of five specific HAPs: naphthalene, benzene, acetaldehyde, formaldehyde and methanol (collectively known as “NBAFM”) from the NEI were “integrated” with the NEI VOC. 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 then 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 HAP VOC 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[18]). 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

[18] 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.

NONHAPVOC-to-NONHAPTOG factors and NONHAPTOG speciation profiles.[19] 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, we create NBAFM species from the no-integrate source VOC emissions using speciation profiles. 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 and no-integrate 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."

In SMOKE, the INVTABLE allows the user to specify the particular HAPs to integrate. Two different INVTABLE files are used for different sectors of the platform. For sectors that had no integration across the entire sector (see Table 3-4), EPA created a "no HAP use" INVTABLE in which the "KEEP" flag is set to "N" for NBAFM pollutants. 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).

[19] 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.

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

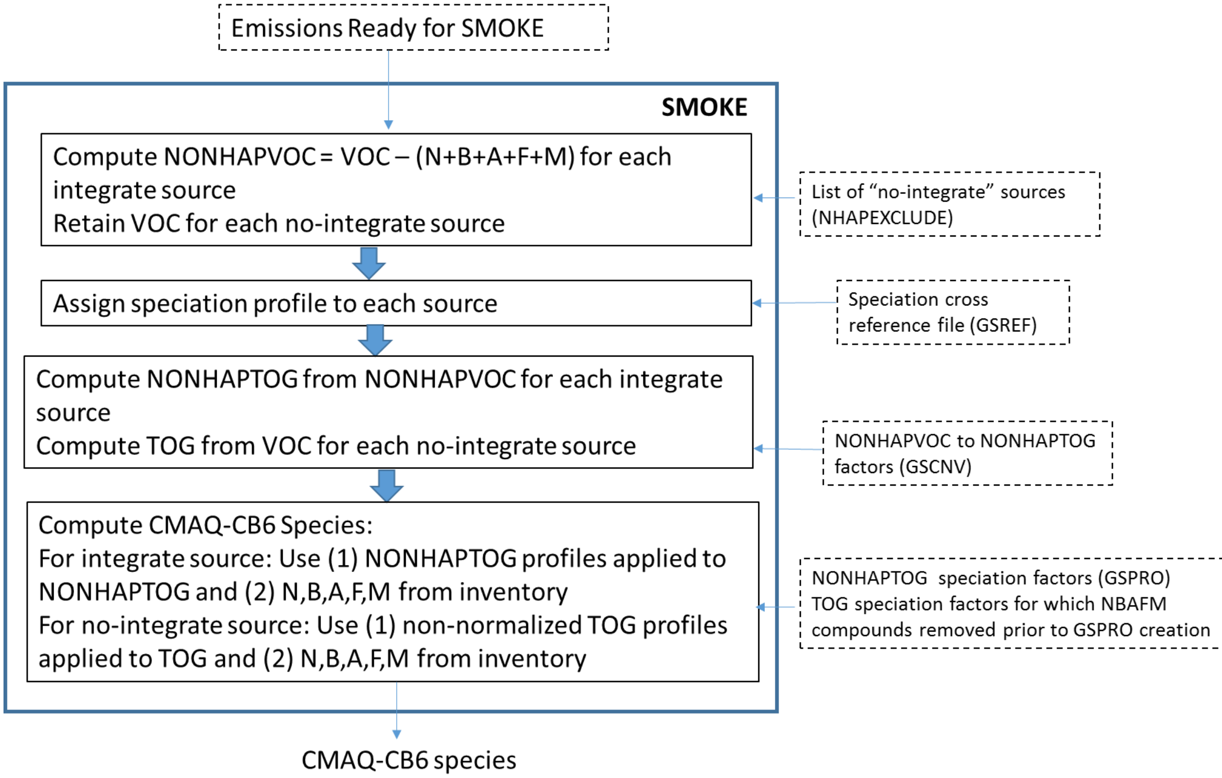


Table 3-4. Integration status of naphthalene, benzene, acetaldehyde, formaldehyde and methanol (NBAFM) for each platform sector

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)
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)
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

Platform Sector	Approach for Integrating NEI emissions of Naphthalene (N), Benzene (B), Acetaldehyde (A), Formaldehyde (F) and Methanol (M)
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 HAPs 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).[20] SMOKE essentially calculates the model-ready species by using the appropriate

[20] 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.

emission factor without further speciation.[21] 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

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 states provided emissions, MOVES-style speciation has been implemented in 2016v2, 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, 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.

[21] 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/.

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 XYLMN and SOAALK species in particular, so post-SMOKE we converted the emissions to CB6-CMAQ 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. BEIS3.7 includes the species (SESQ) that is mapped to the BEIS model species SESQT (Sesquiterpenes). The profile code associated with BEIS3.7 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.[22]

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 are slated to be added to SPECIATE5.2. These profiles are used in the 2016v2 platform and are listed in Appendix B. Additional documentation is available in the SPECIATE database (for the SPECIATE5.1 profiles).

For the profiles planned to be released in SPECIATE 5.2:

1) 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 Southern Ute Indian Tribe Comprehensive Emissions Inventory for Criteria Pollutants, Hazardous Air Pollutants, and Greenhouse Gases."[23]

2) 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-

[22] https://github.com/USEPA/CMAQ/blob/main/CCTM/src/biog/beis3/gspro_biogenics.txt.
[23] https://www.southernute-nsn.gov/wp-content/uploads/sites/15/2019/12/191203-SUIT-CY2017-Emissions-Inventory-Report-FINAL.pdf.

905[24].” 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 planned for SPECIATE 5.2.

3) 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, https://www.tceq.texas.gov/assets/public/implementation/air/rules/Flare/2010flarestudy/2010-flare-study-final-report.pdf) 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 particular county/SCC combinations using the SMOKE feature discussed in 3.2.1.1 that allows multiple profiles to be combined within the chemical speciation cross reference file (GSREF) by pollutant, state/county, and SCC. 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 platform. These fractions can vary by county FIPS, because they depend on the level of controls, which is an input to the Speciation Tool.

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	

[24] http://doi.org/10.1016/j.scitotenv.2017.11.161.

Profile Code	Description	Region (if not in profile name)
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	
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[25]	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
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 NEITSD. 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.

[25] 95333a replaced 95333. This correction was made to remove alcohols due to suspected contamination. Additional information is available in SPECIATE.

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 2016v2 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 future 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[26]	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
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[27]	10,40,41,42,46,47,48

[26] 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.

[27] 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.

Profile	Profile Description	Model Years	ProcessID	FuelSubTypeID	RegClassID
95120[m]	Liquid Diesel	19602060	11	20,21,22	0
95120[m]	Liquid Diesel	19602060	12,13,18,19	20,21,22	10,20,30,40,41,42,46,47,48
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	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)

Fuel Subtype ID	Fuel Subtype Descriptions
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. Of particular note for the 2016v7.2 beta and regional haze platforms, the nonroad $PM_{2.5}$ speciation was updated as discussed later in this section. Most of the PM profiles come from the 911XX series (Reff et. al, 2009), which include updated AE6 speciation.[28] Starting with the 2014v7.1 platform, profile 91112 (Natural Gas

[28] 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.

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 (to be 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 is the Sugar Cane Pre-Harvest Burning Mexico profile (SUGP02). This profile falls under the sector ptagfire and are included in SPECIATE 5.1.

Additionally, a series of regional fire profiles have been added to SPECIATE 5.1 and are used in 2016v2. 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

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

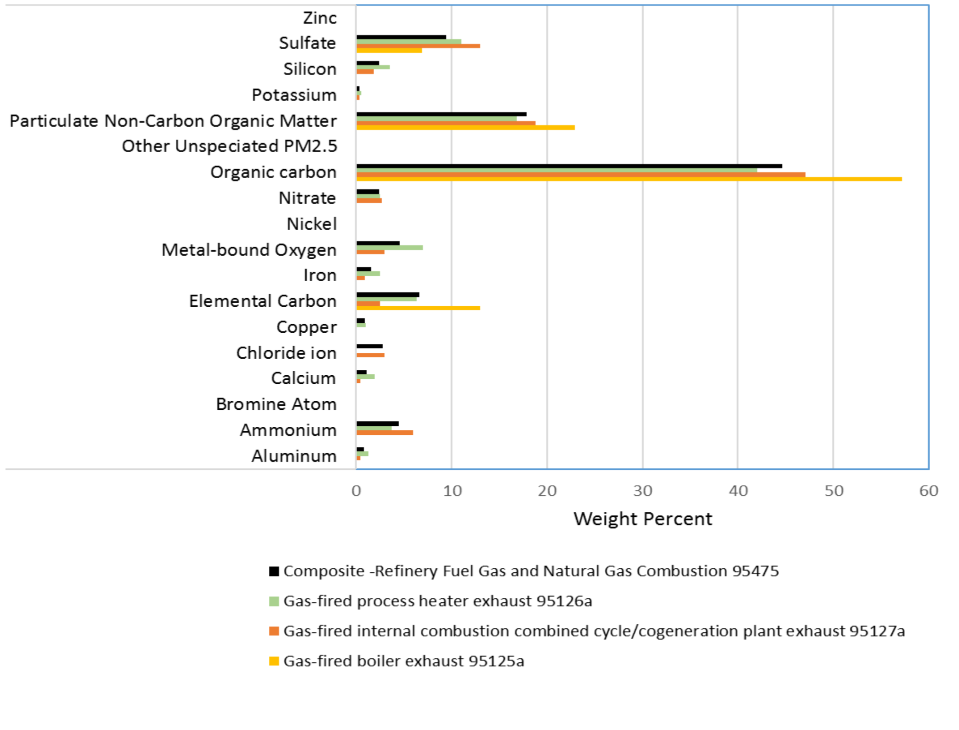
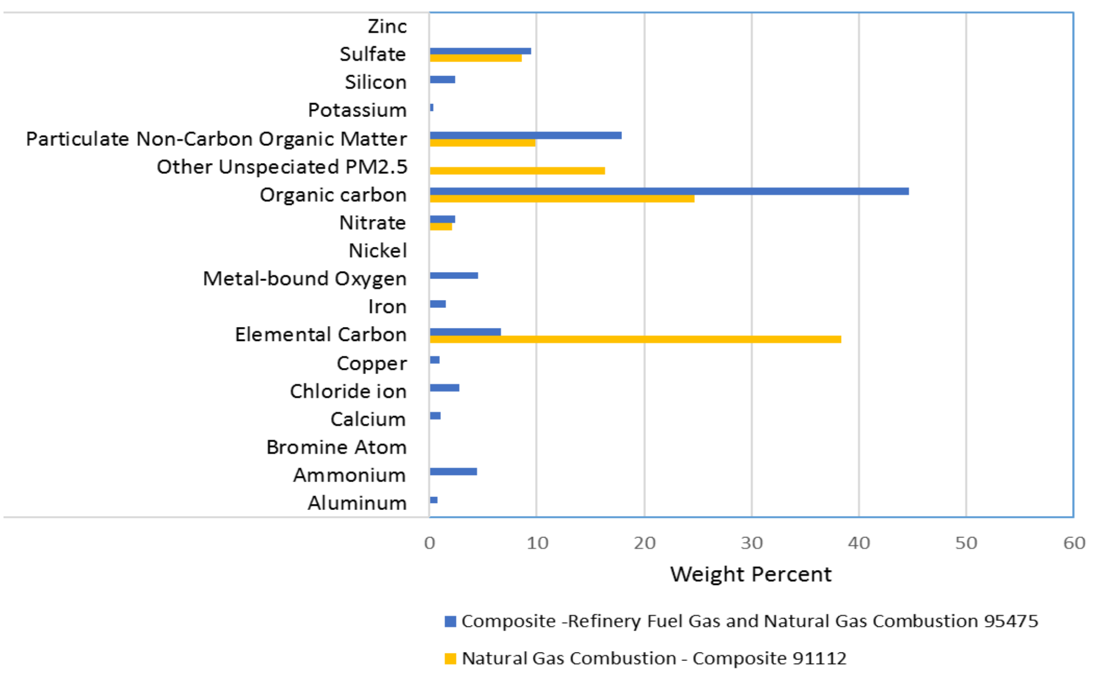


Figure 3-4. Comparison of PM profiles used for Natural gas combustion related sources



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.[29] 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).

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

[29] 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 (including 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

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.

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
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]
solvents	Annual	Yes	aveday	aveday	No

[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.

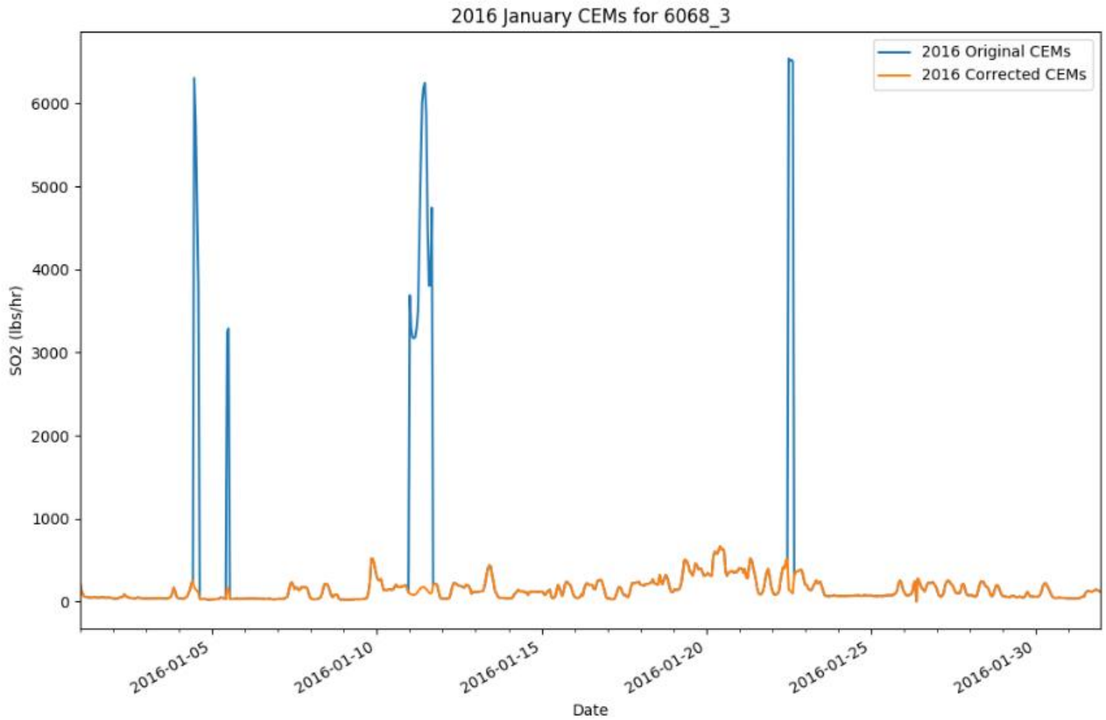
SMOKE prevents the application of temporal profiles on top of the "native" resolution of the inventory. For example, a monthly inventory should not have annual-to-month temporal allocation applied to it; rather, it should only have month-to-day and diurnal temporal allocation. This becomes particularly 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 and 2016v2 platforms, the small EGU temporalization process was improved to also consider 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

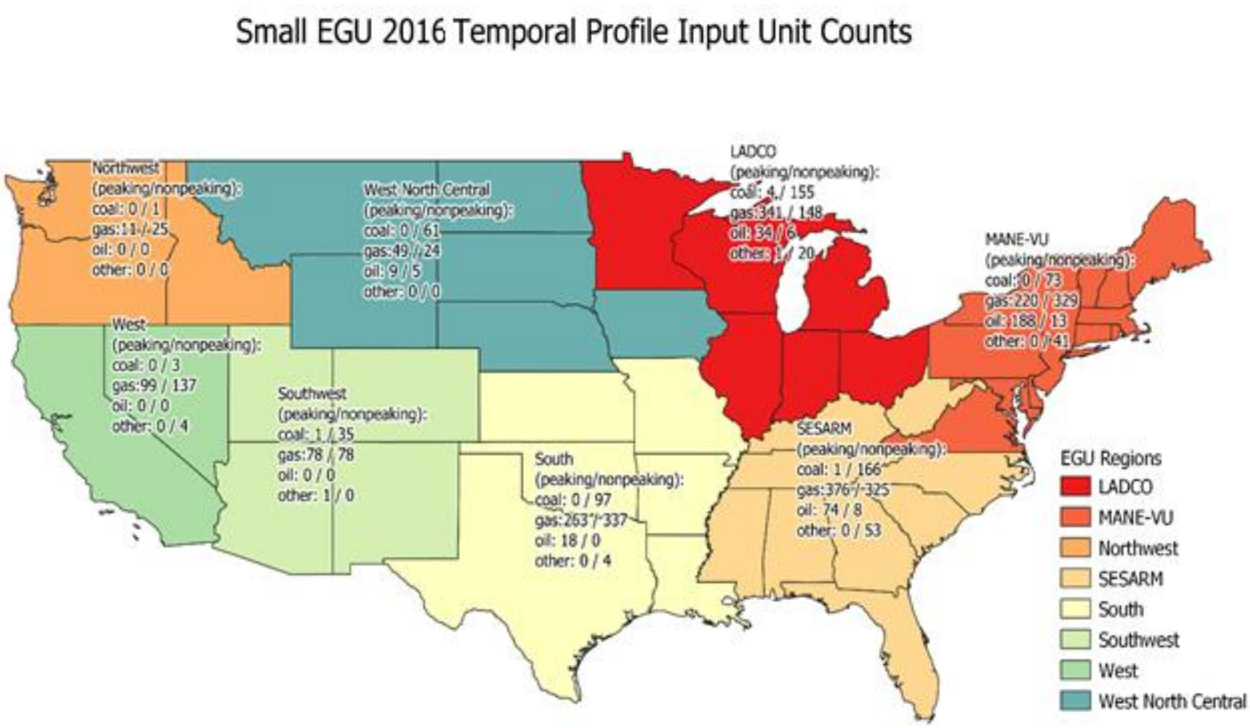
$$Annual\ Unit\ Output\ (MW) = \frac{\sum_{i=0}^{8760} \frac{Hourly\ HI}{(BTU)} * 1000\ \left(\frac{MW}{kW}\right)}{NEEDS\ Heat\ Rate\ \left(\frac{BTU}{kWh}\right)} \qquad \text{Equation 3-2}$$

Unit Capacity Factor

$$Capacity\ Factor = \frac{Annual\ Unit\ Output\ (MW)}{NEEDS\ Unit\ Capacity\ \left(\frac{MW}{h}\right) * 8760\ (h)} \qquad \text{Equation 3-3}$$

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

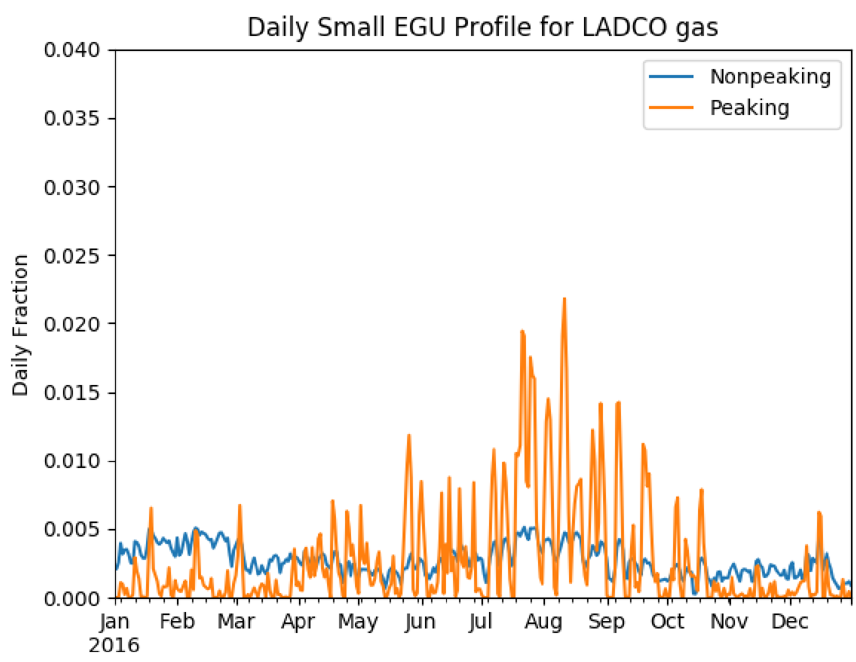
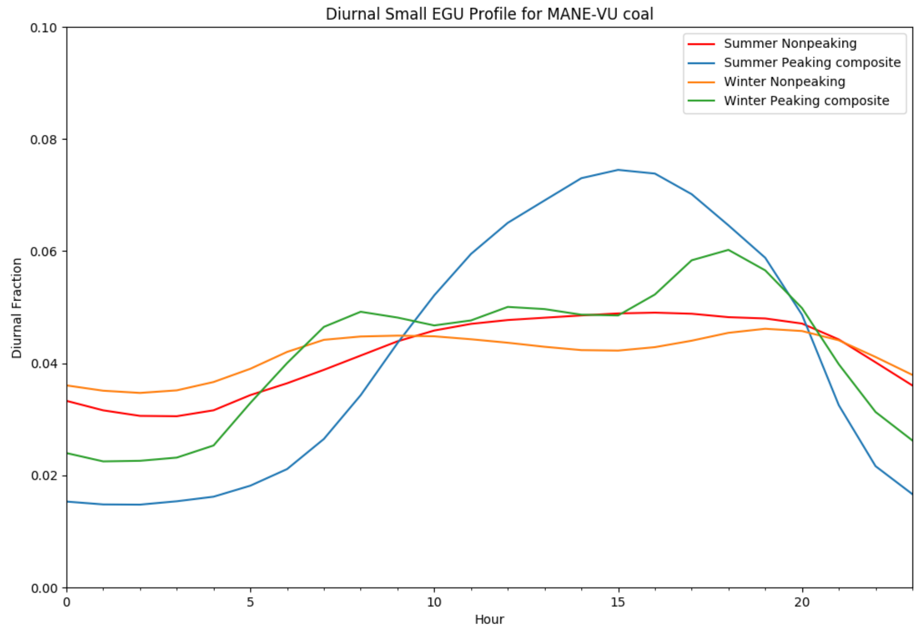
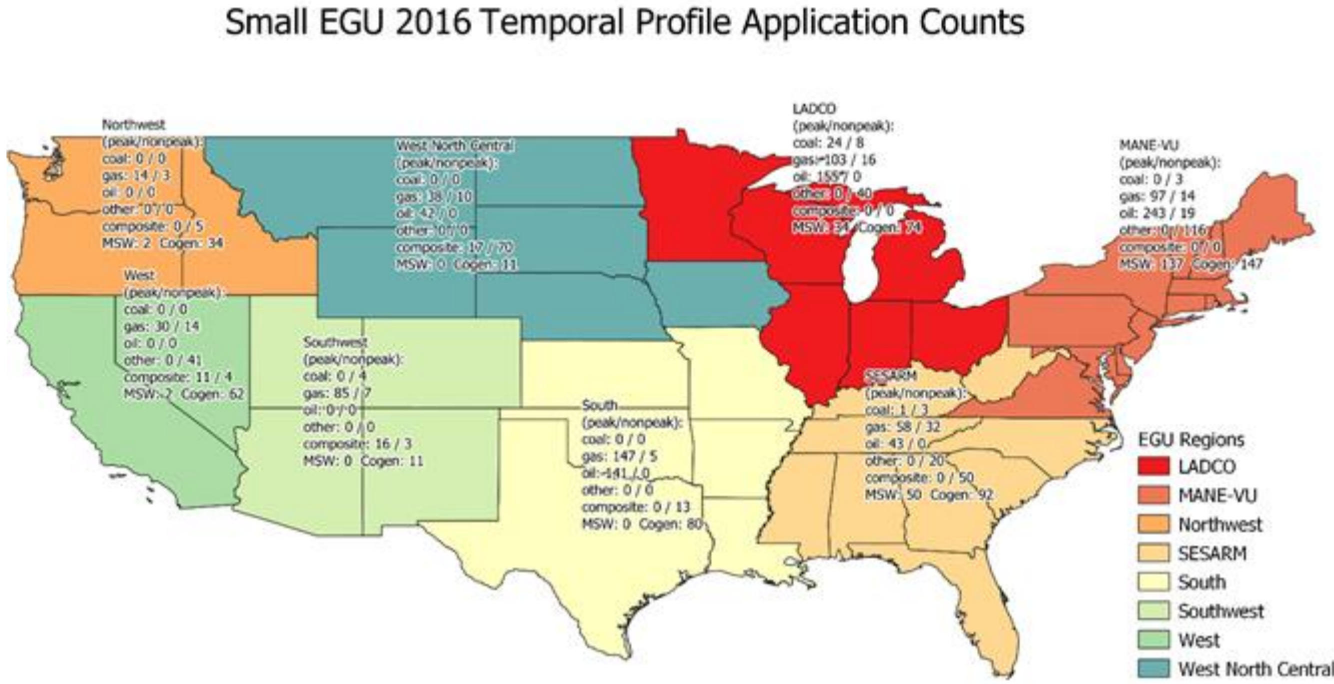


Figure 3-8. Example Diurnal Temporal Profiles for the MANE-VU Region and the Coal Fuel Type



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 Future year temporal allocation of EGUs

For future 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 Integrated Planning Model (IPM) for all units. The winter shoulder was newly separated from the winter months in 2016v2 platform. The seasonal emissions for the future 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 future-year emission projections into future-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 future 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 future 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 future 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 future-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 future 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 future 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 future 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 future year Flat File. Any pollutants other than NO_x and SO_2 were temporally allocated using heat input. Through the temporal allocation process, the future year emissions will have the same temporal pattern as the base year CEMS data, where available, while the future-year seasonal total emissions for each unit match the future-year unit-specific projection for each season (see example in Figure 3-10). The future year IPM output for

2025 maps to the year 2026 and the IPM output for 2030 maps to year 2032 and were therefore used for the respective 2026 and 2032 modeling cases.

In cases when the emissions for a particular unit are projected to be substantially higher in the future 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 future 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. Future Year Emissions Follow the Pattern of Base Year Emissions

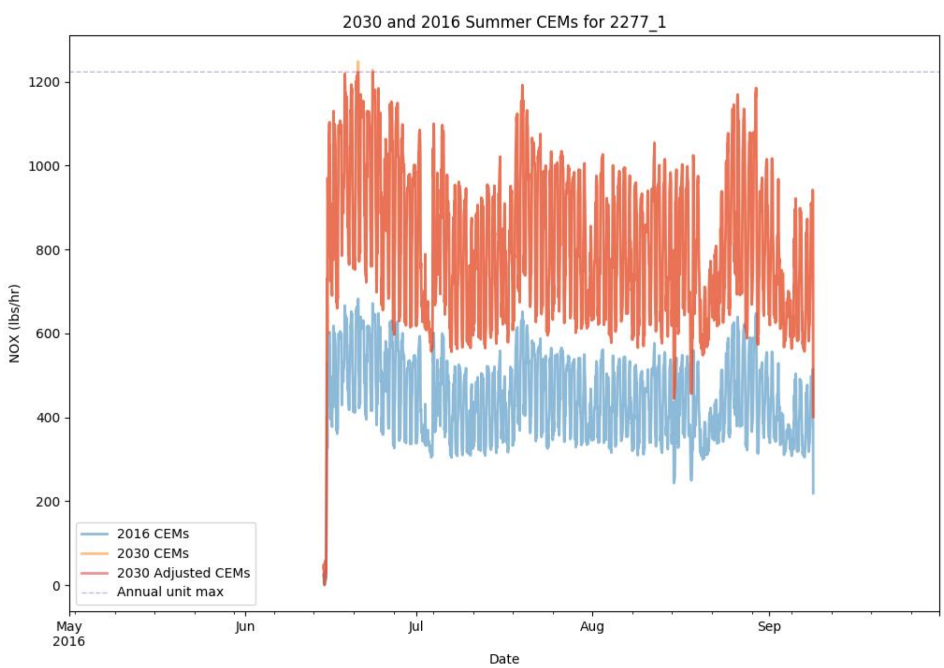
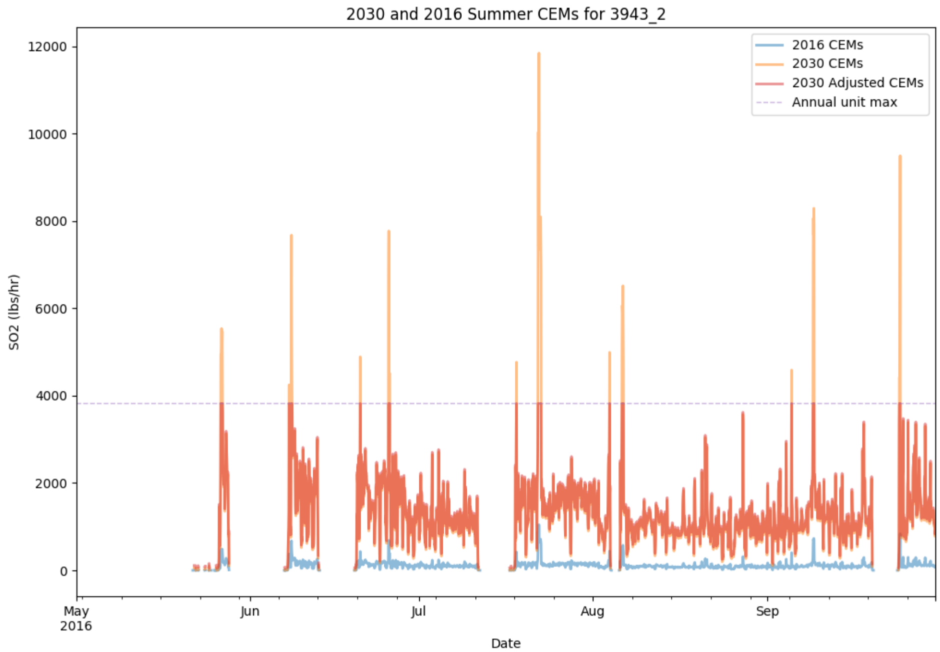


Figure 3-11. Excess Emissions Apportioned to Hours Less than the Historic Maximum



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

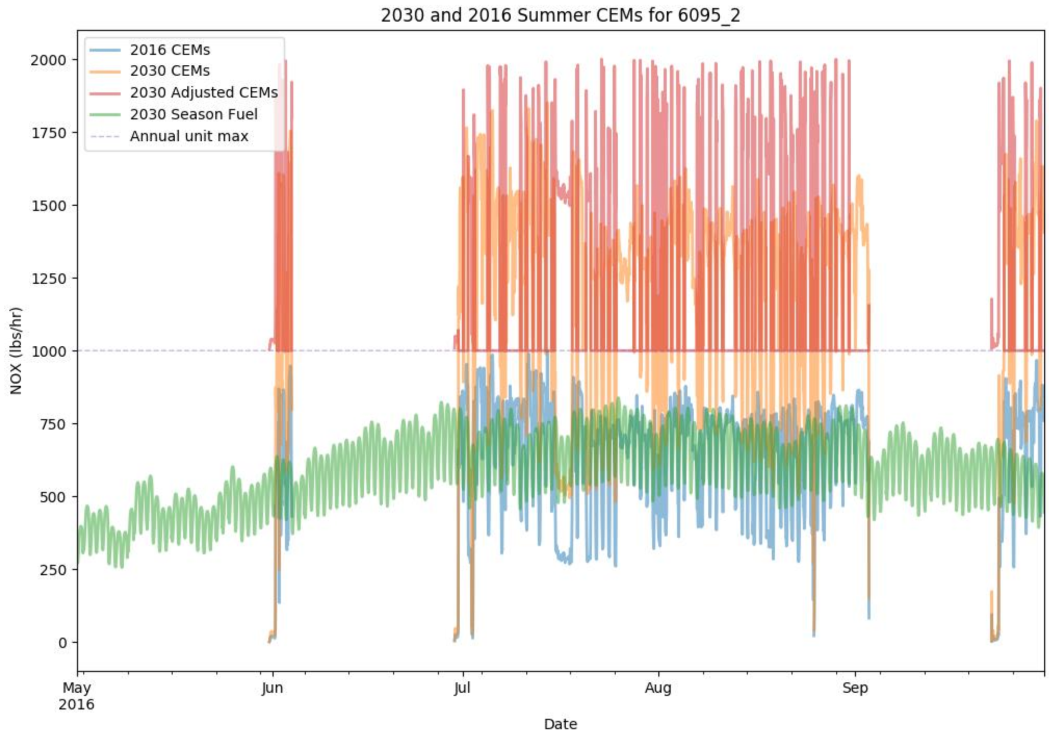
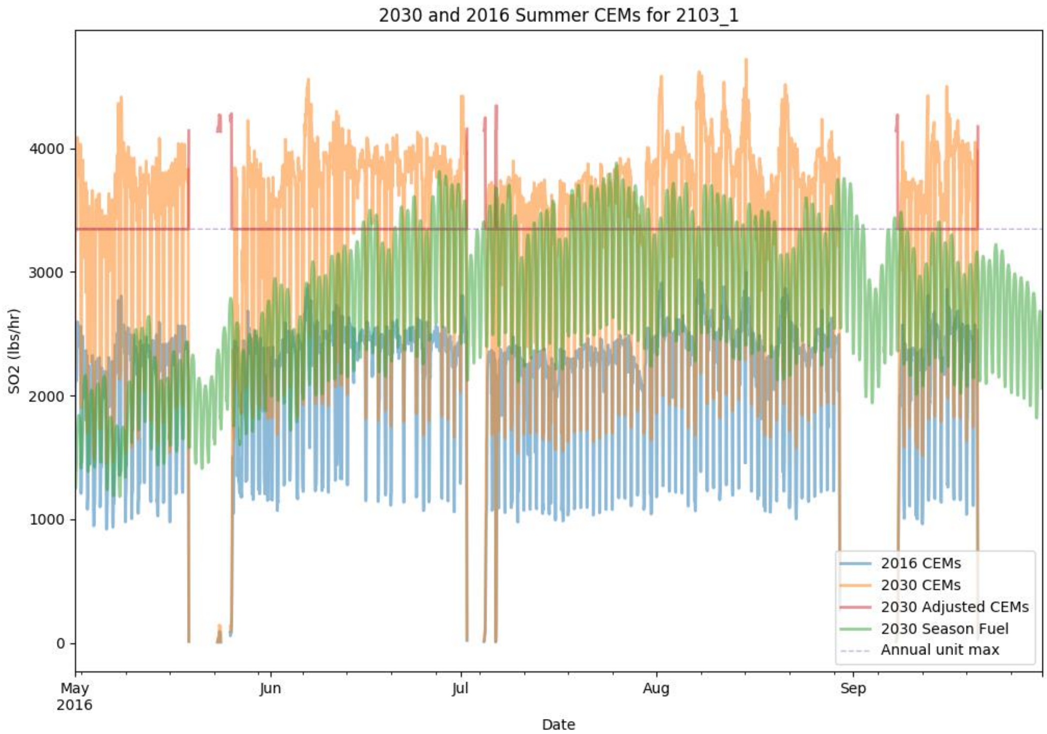


Figure 3-13. Regional Profile Applied, but Exceeds Historic Maximum in Some Hours



3.3.3 Airport Temporal allocation (airports)

Airport temporal profiles were updated in 2014v7.0 and were kept the same for the 2016v2 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

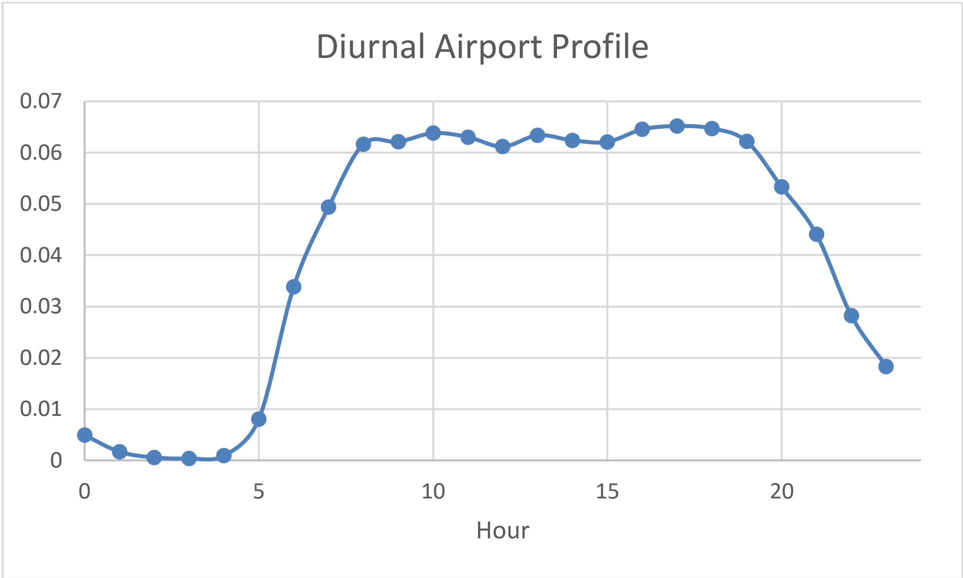


Figure 3-15. Weekly profile for all Airport SCCs

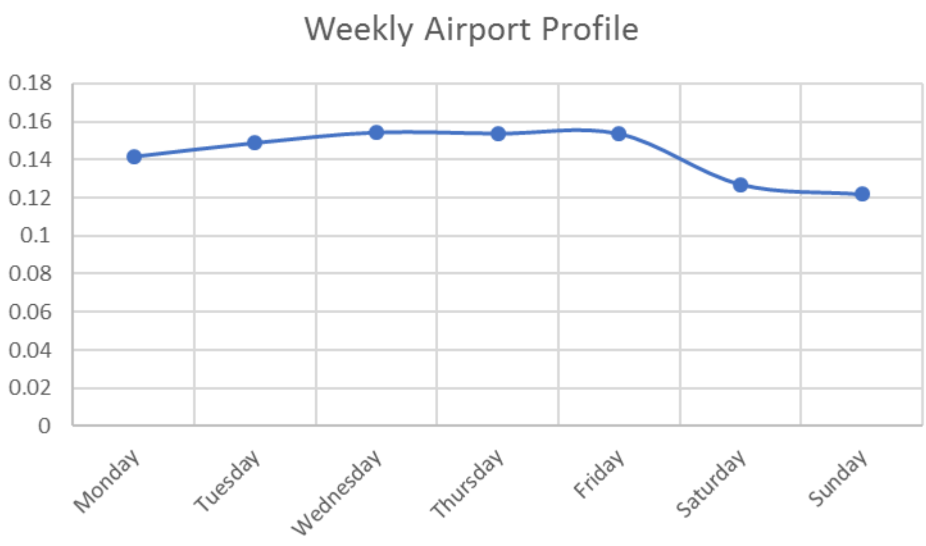


Figure 3-16. Monthly Profile for all Airport SCCs

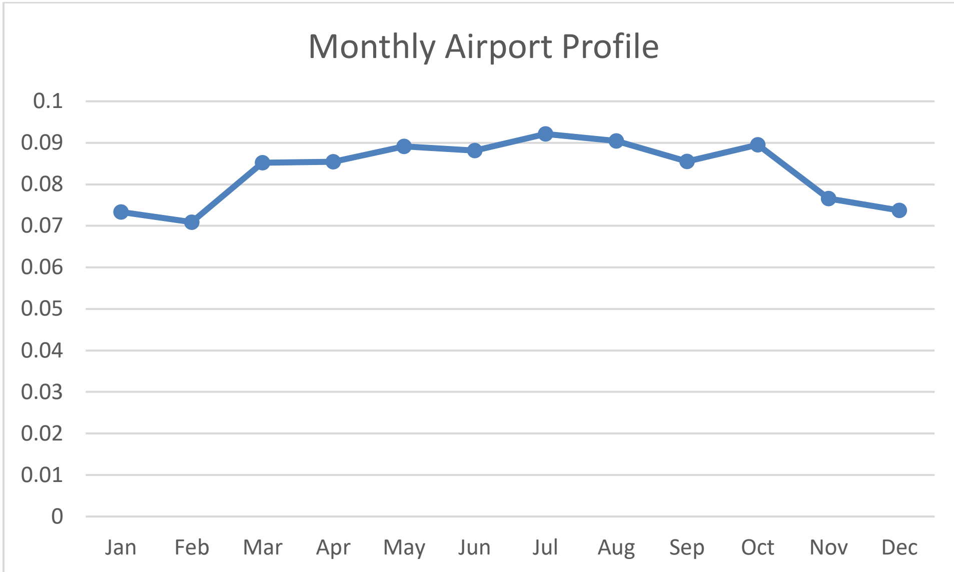
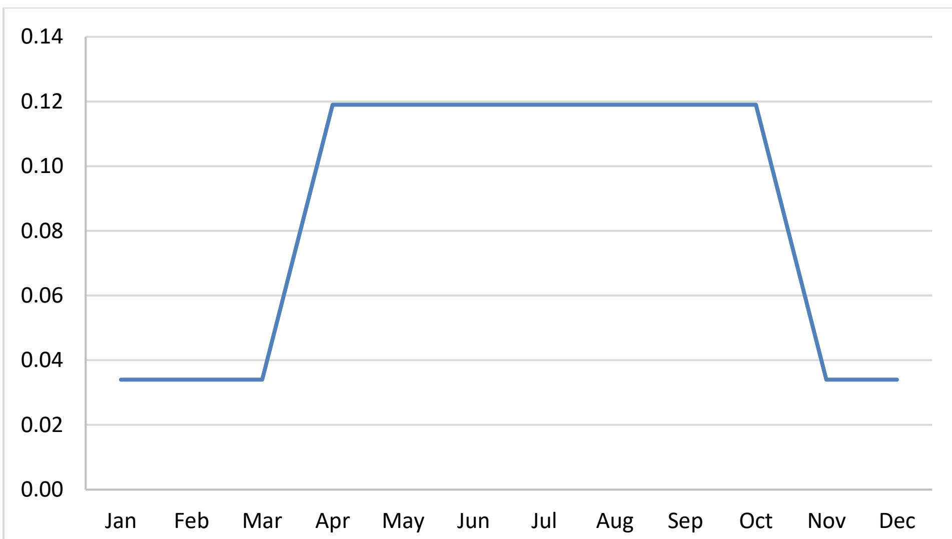


Figure 3-17. Alaska Seaplane Profile



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.

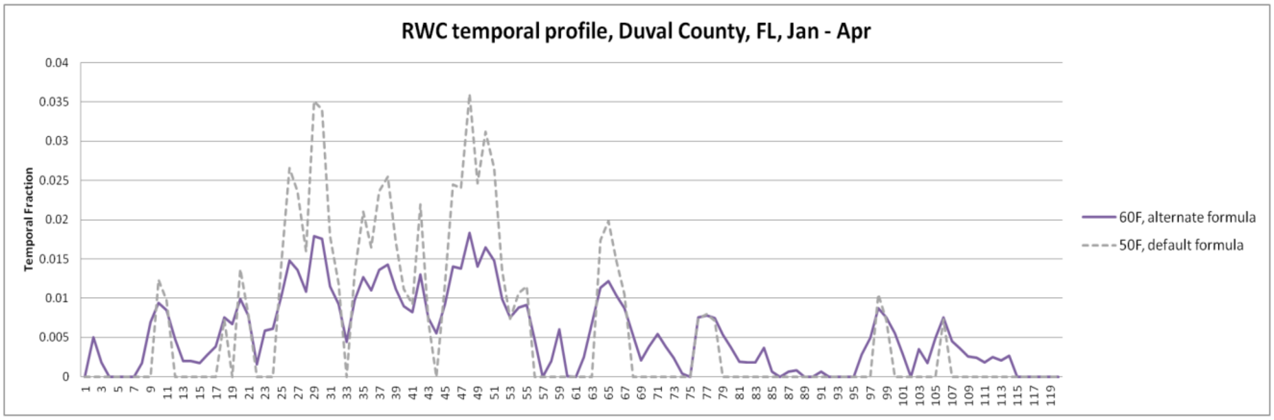
For the RWC algorithm, Gentpro uses the daily minimum temperature to determine the temporal allocation of emissions to days of the year. Gentpro was used to create an annual-to-day temporal profile for the RWC sources. These generated profiles distribute annual RWC emissions to the coldest days of the 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.

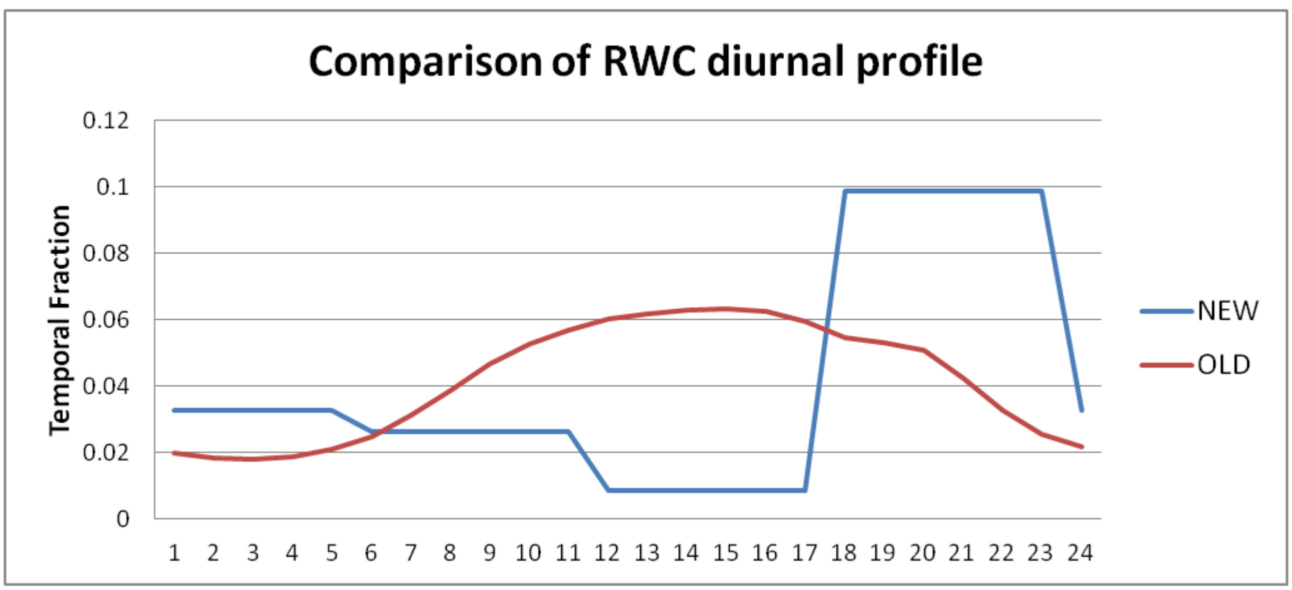
Figure 3-18 illustrates the impact of changing the temperature threshold for a warm climate county. The plot shows the temporal fraction by day for Duval County, Florida, for the first four months of 2007. The default 50 ˚F threshold creates large spikes on a few days, while the 60 ˚F threshold dampens 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 (https://s3.amazonaws.com/marama.org/wp-content/uploads/2019/11/04184303/Open_Burning_Residential_Areas_Emissions_Report-2004.pdf). 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.

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)

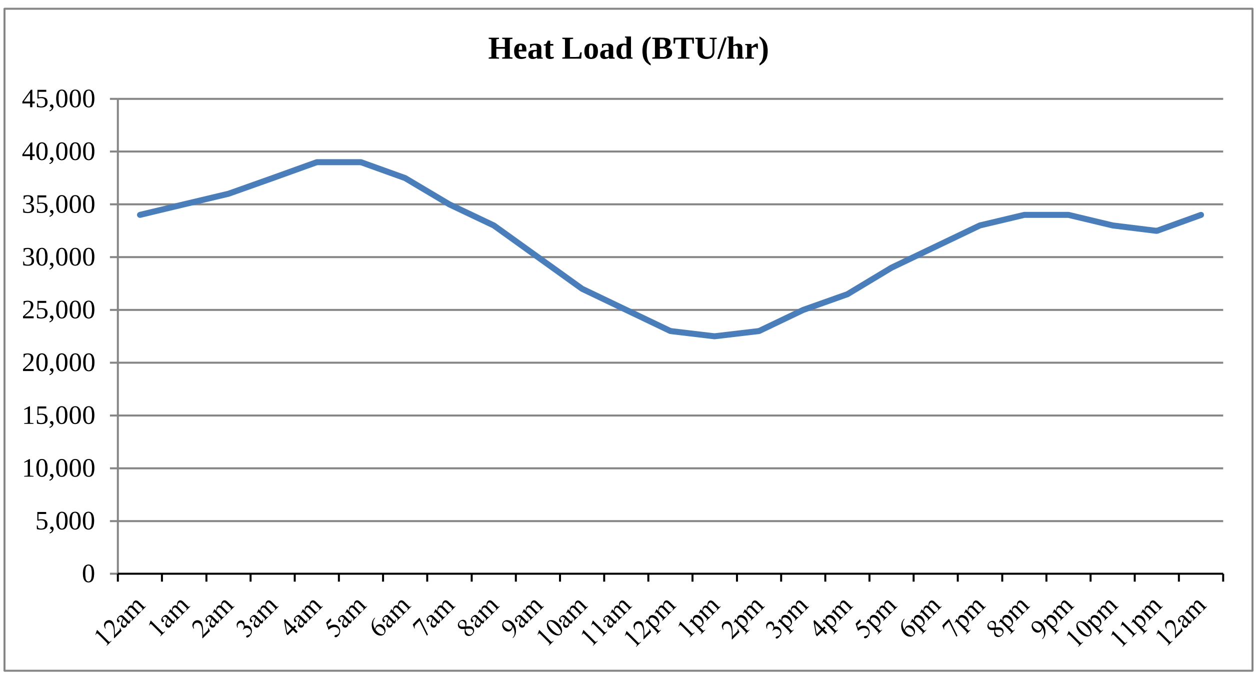


Figure 3-21. Day-of-week temporal profiles for OHH and Recreational RWC

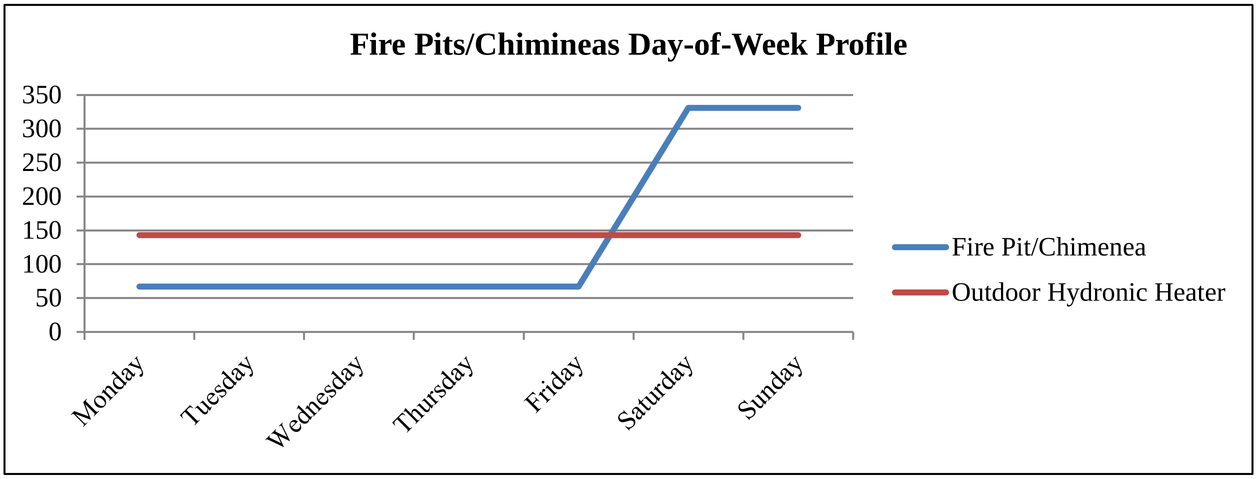
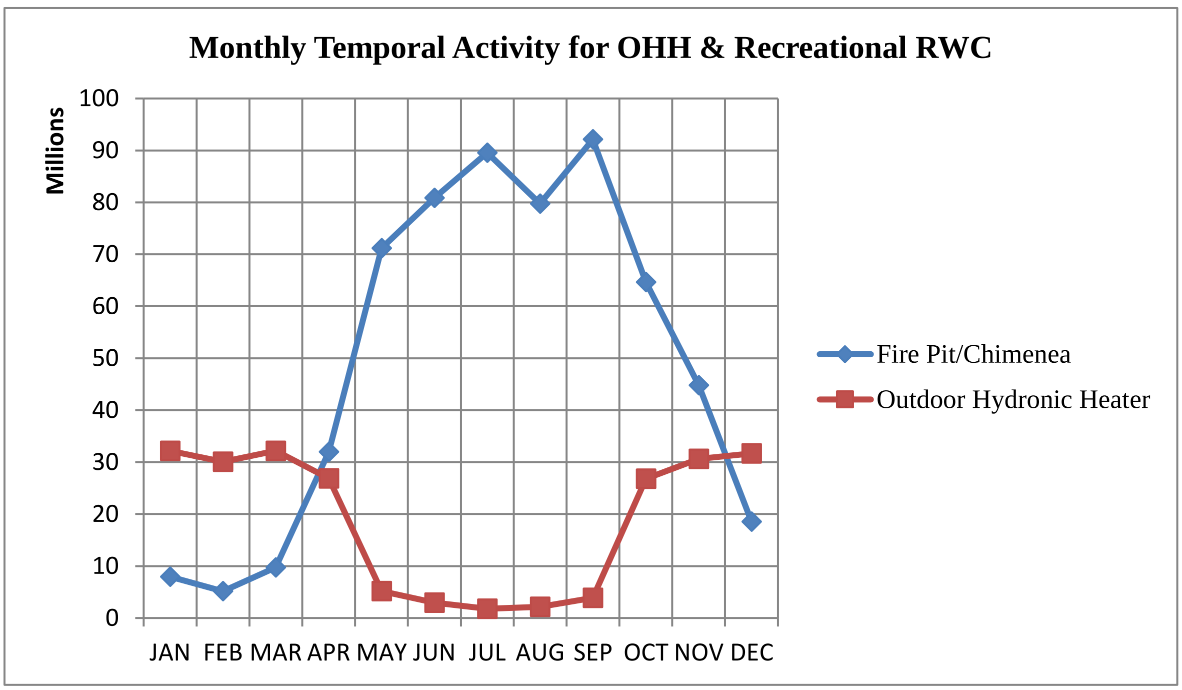


Figure 3-22. Annual-to-month temporal profiles for OHH and recreational RWC



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

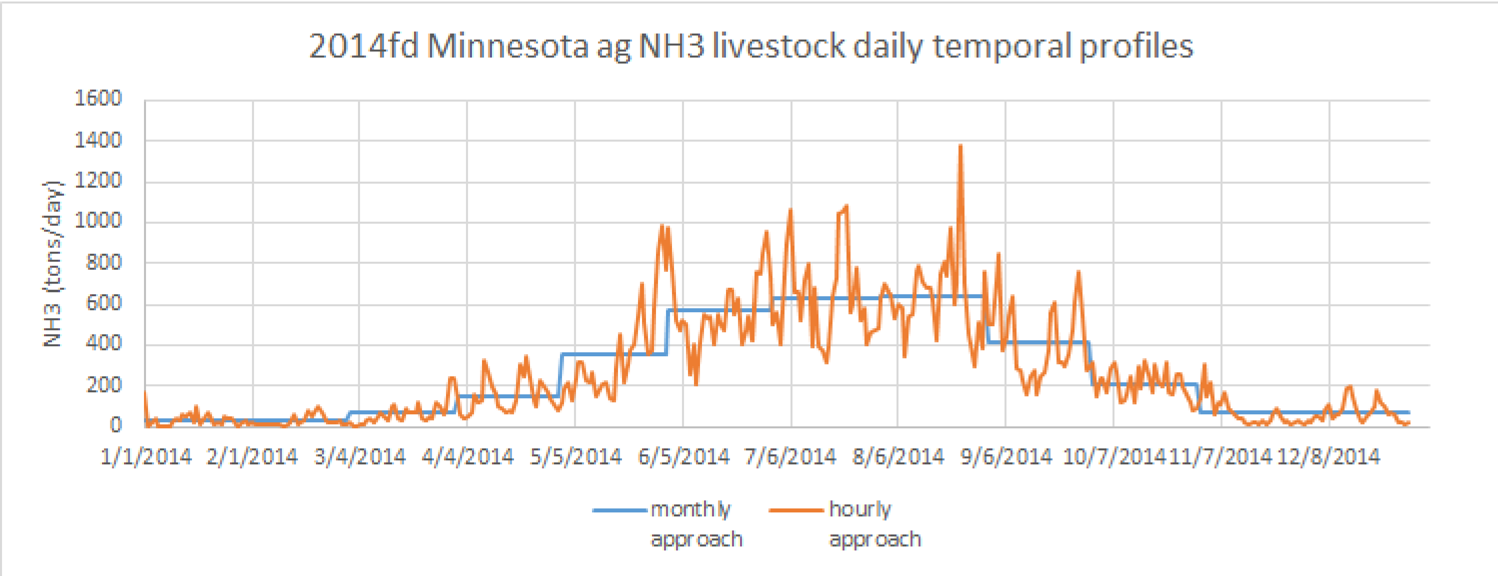
$PE_{i,h} = E_{i,h} / Sum(E_{i,h})$ Equation 3-5

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 were 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)

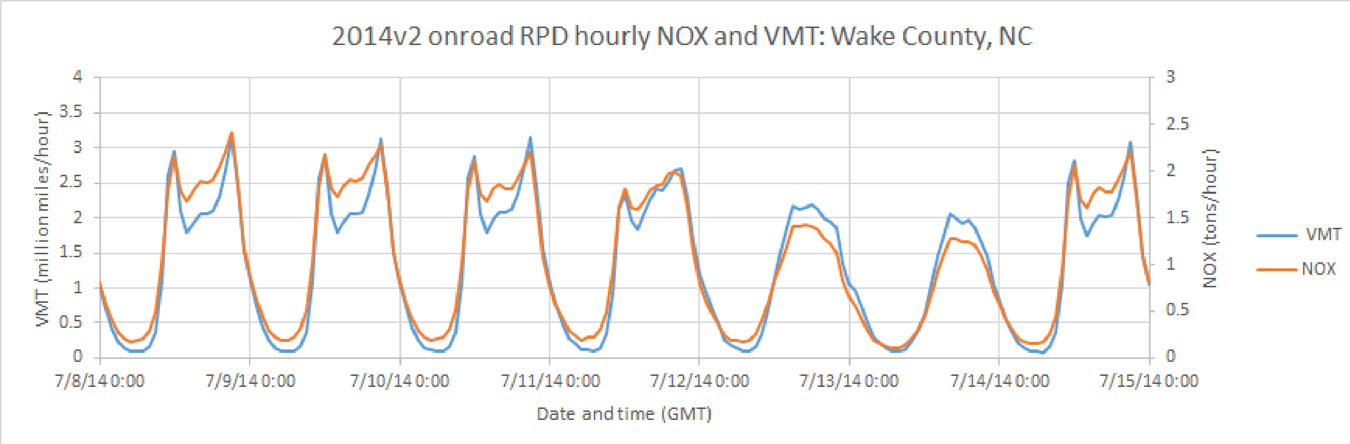
For the onroad sector, the temporal distribution of emissions is a combination of traditional temporal profiles and the influence of meteorology. This section will discuss both the meteorological influences and the development of the temporal profiles for this platform.

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.

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, and RPP) processes use the gridded meteorology (MCIP) either directly or indirectly. For RPD, RPV, and RPH, 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, 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

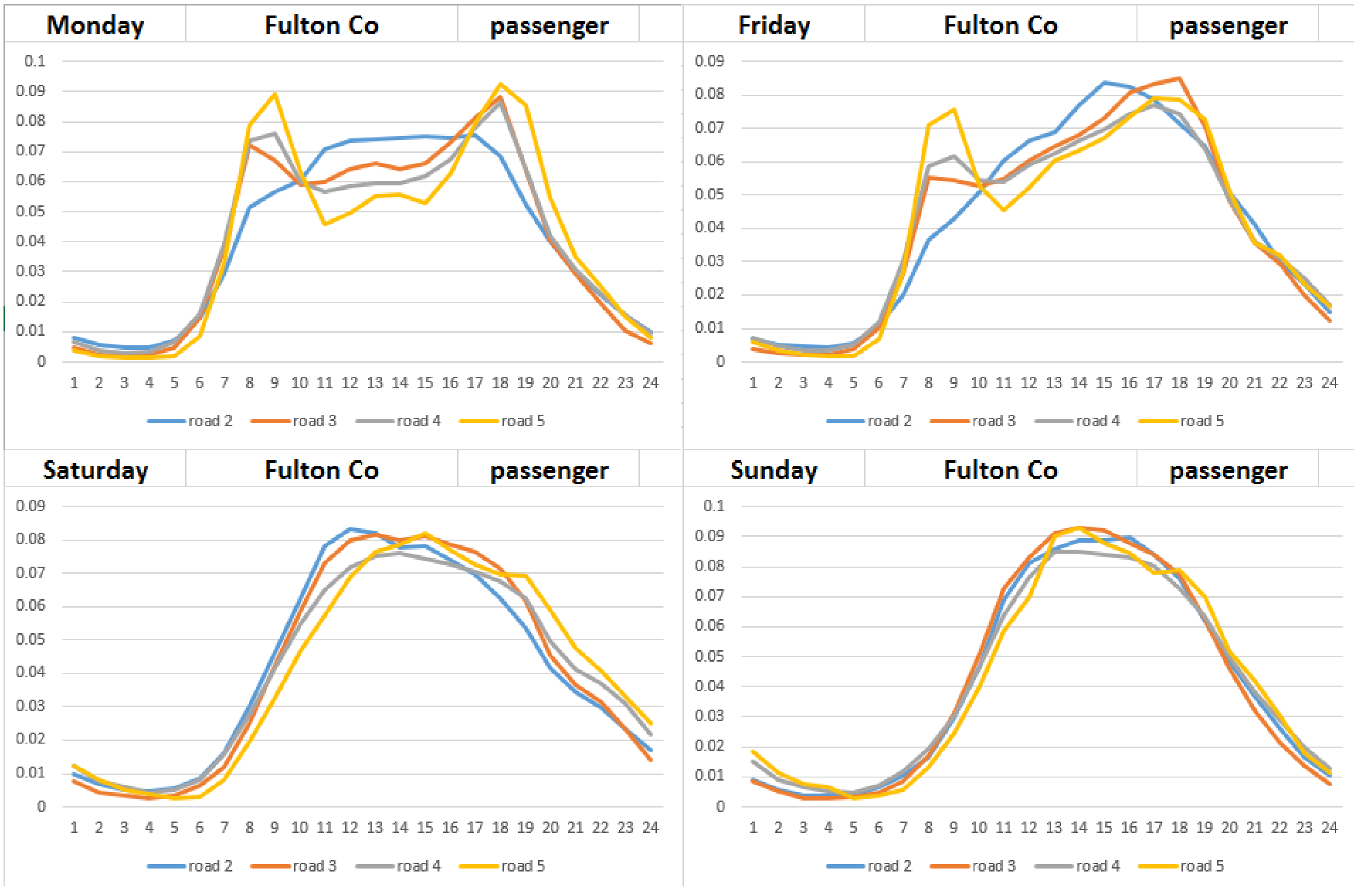
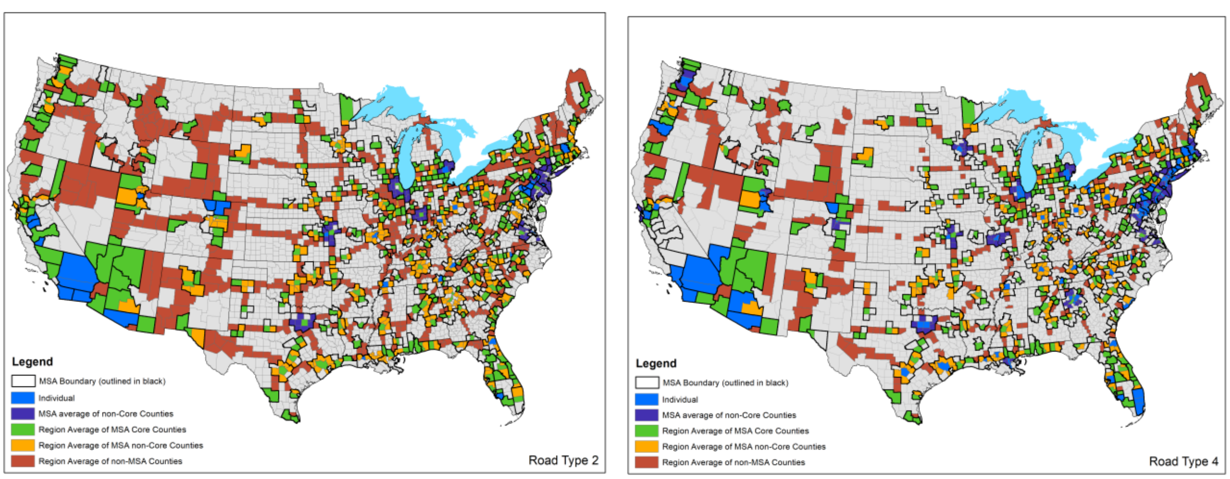


Figure 3-26. Methods to Populate Onroad Speeds and Temporal Profiles by Road Type



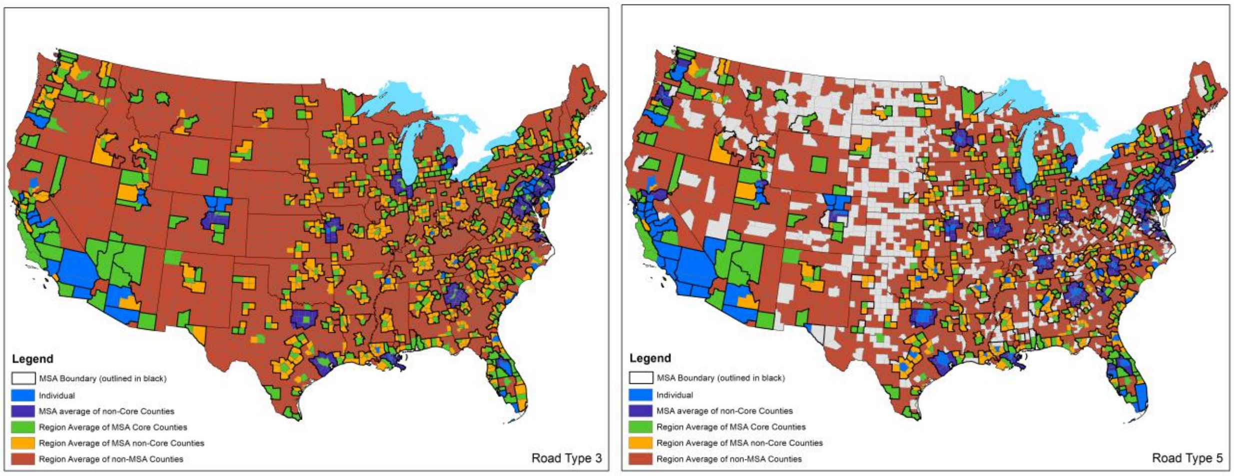
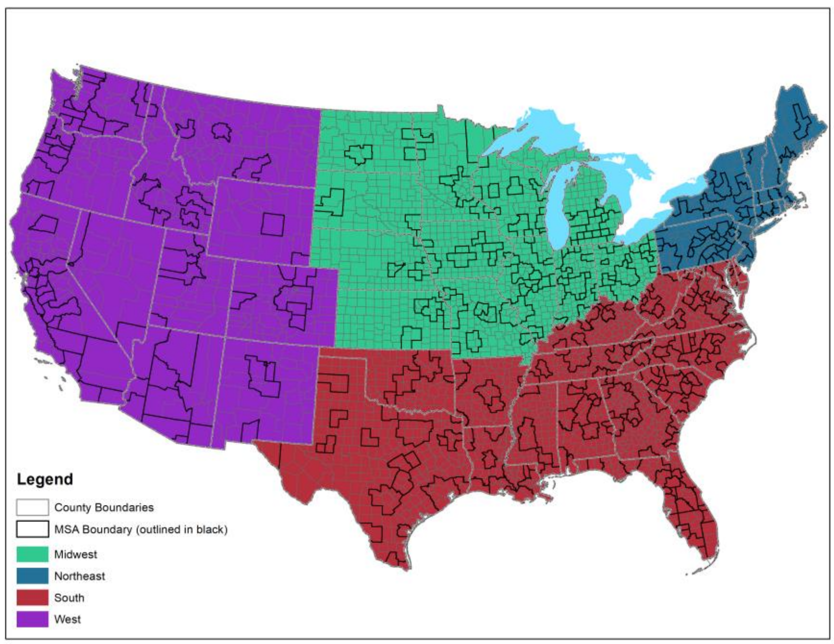


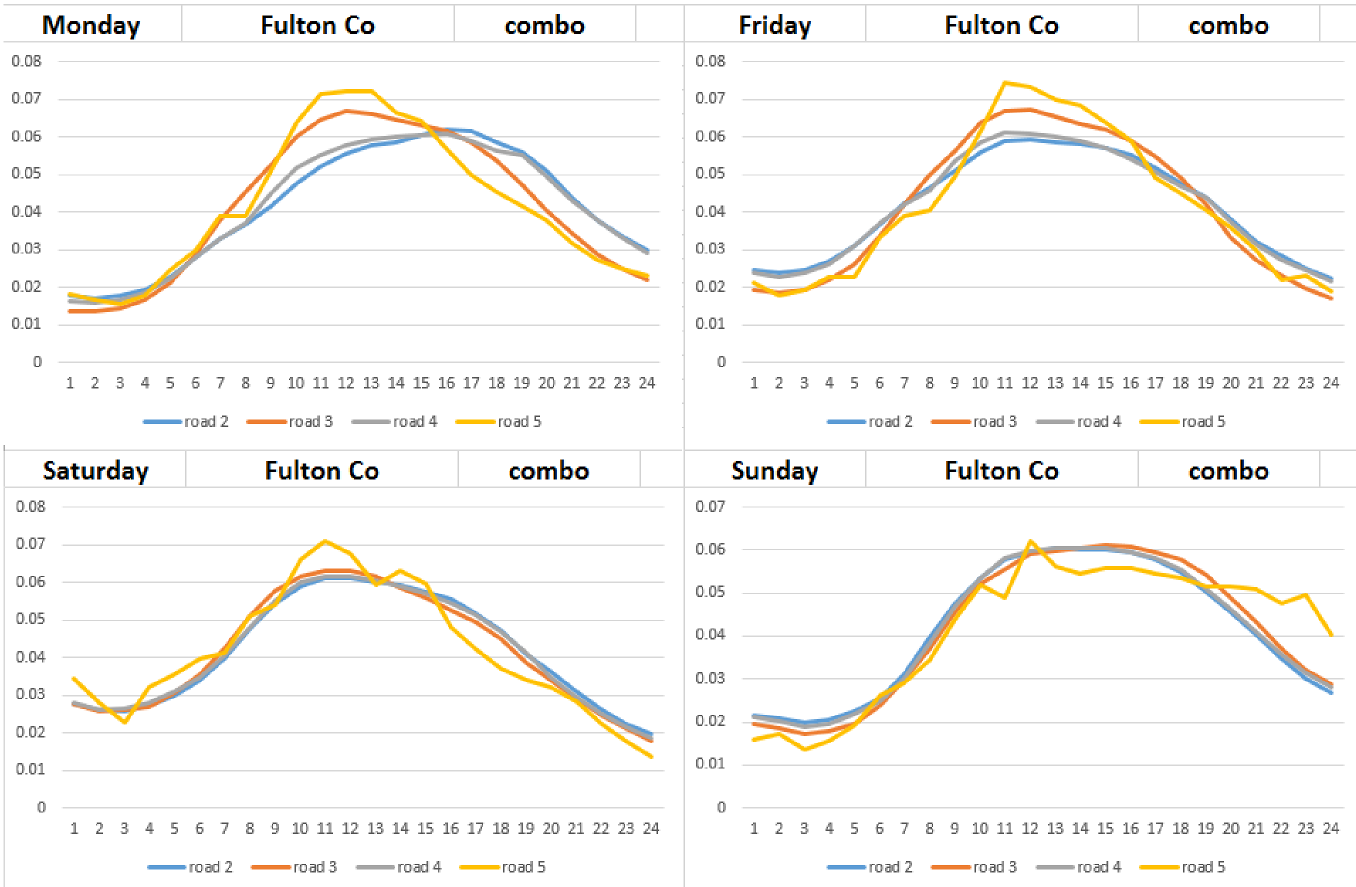
Figure 3-27. Regions for computing Region Average Speeds and Temporal Profiles



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,[30] 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.

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



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 int the 2016 platform, 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.

[30] 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 3-29. Example Nonroad Day-of-week Temporal Profiles

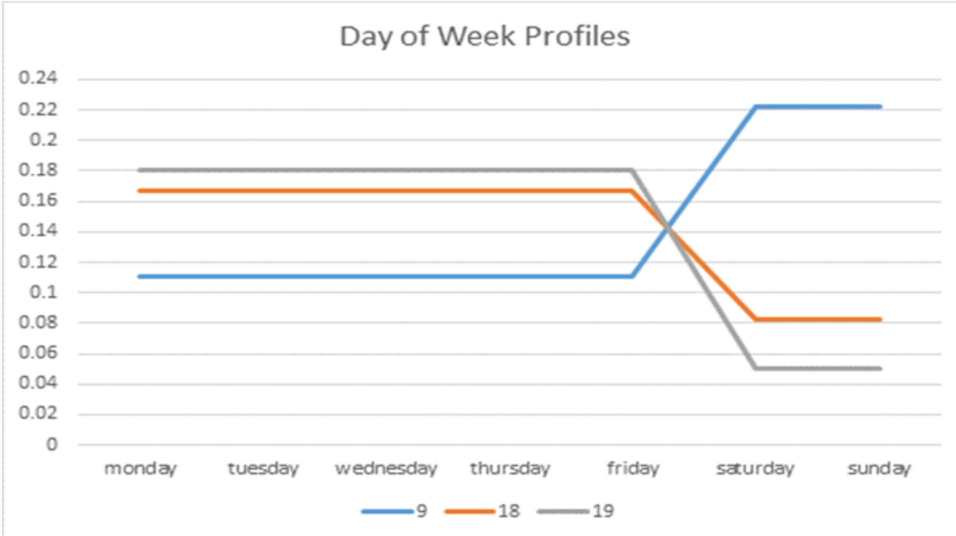
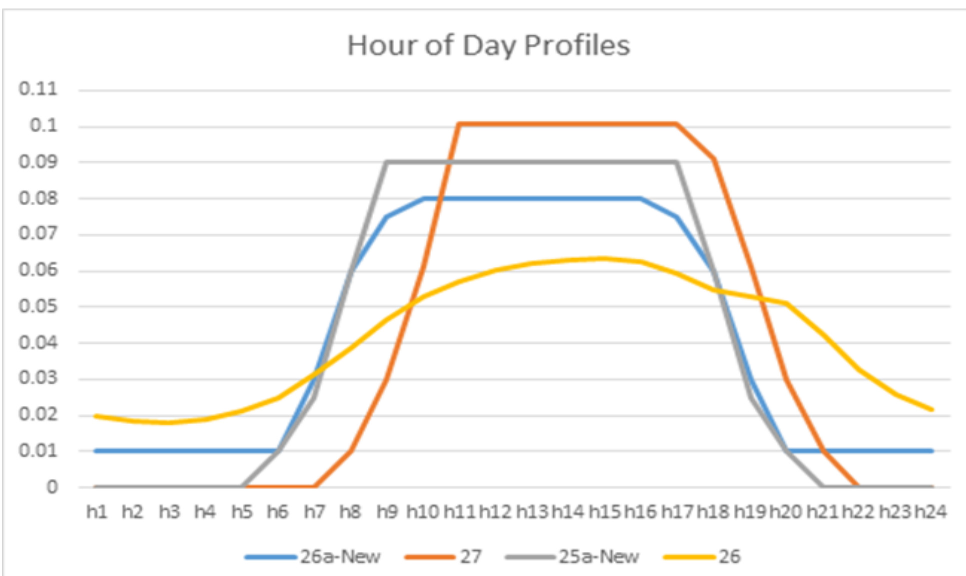


Figure 3-30 shows the previously existing temporal profiles 26 and 27 along with new temporal profiles (25a and 26a) which have lower emissions overnight. In the 2016 platform, construction sources previously used profile 26 and were updated to use profile 26a. Commercial lawn and garden and agriculture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

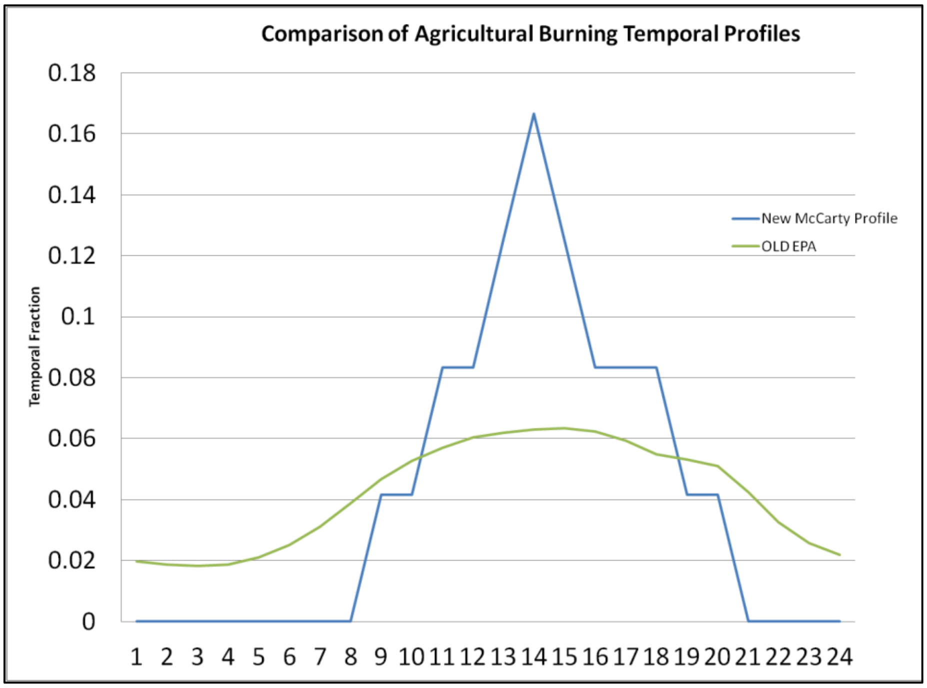
Biogenic emissions in the beis sector vary by every day of the year because they are developed using meteorological data including temperature, surface pressure, and radiation/cloud data. The emissions are computed using appropriate emission factors according to the vegetation in each model grid cell,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

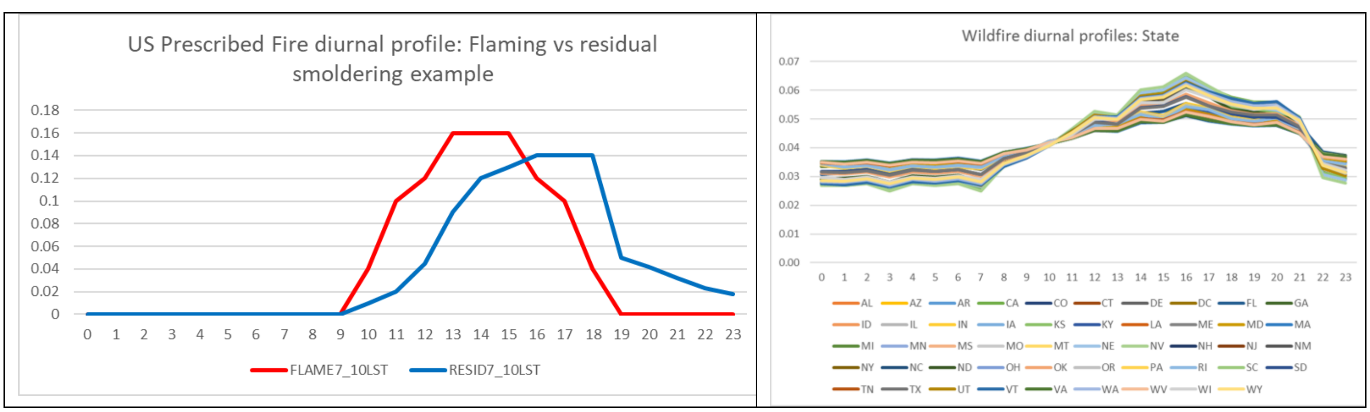
Figure 3-31. Agricultural burning diurnal temporal profile



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 modeling platform. The wildfire diurnal profiles are similar but vary according to the average meteorological conditions in each state. The 2016v2 platform used updated diurnal profiles for prescribed profile that better reflect flaming and residual smoldering phases and average burn practices. These flaming and residual smoldering diurnal profiles do 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 platform, 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. For the modeling platform, 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 EPA updated surrogates to use circa 2014 to 2016 data wherever possible. For Mexico, updated spatial surrogates were used as described below. For Canada, updated surrogates were provided by Environment Canada for the 2016v7.2 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, special considerations are taken to include Alaska emissions in 36-km modeling.

Documentation of the origin of the spatial surrogates for the platform is provided in the workbook US_SpatialSurrogate_Workbook_v07172018 which is available with the reports for the 2014v7.1 platform. 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 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 landuse 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. This 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 were updated to represent 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 and the surrogate data and were further updated for the 2016 platform;

- Spatial surrogates 201 through 244, which concern road miles, annual average daily traffic (AADT), and truck stops, were further updated for the 2016 beta and regional haze platforms.
- Correction was made to the water surrogate to gap fill missing counties using the 2006 National Land Cover Database (NLCD);
- A public schools surrogate was added in 2016v2 (#508);
- Aside from the new 508, the use of 500 series surrogates 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 Tool DB is available at https://www.cmascenter.org/surrogate_tools_db/.

Table 3-21. U.S. Surrogates available for the 2016v1 and 2016v2 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
271	NTAD Class 1 2 3 Railroad Density	*697*	*Oil Production at Gas Wells*

Code	Surrogate Description	Code	Surrogate Description
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). On-network used AADT data and off network used 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. This surrogate's underlying data were updated for use in the 2016 platforms to include additional data sources and corrections based on comments received.

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
2694	WRAP Oil production at oil wells
2695	WRAP Well count - oil wells

Surrogate Code	Surrogate Description
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	1,183,387	0	0	0	0
livestock	310	NLCD Total Agriculture	2,493,166	0	0	0	224,459
nonpt	100	Population	34,304	0	0	0	208
nonpt	150	Residential Heating - Natural Gas	42,973	219,189	3,632	1,442	13,296
nonpt	170	Residential Heating - Distillate Oil	1,563	31,048	3,356	41,193	1,051
nonpt	180	Residential Heating - Coal	20	101	53	1,086	111
nonpt	190	Residential Heating - LP Gas	111	33,230	175	705	1,292
nonpt	239	Total Road AADT	0	22	541	0	306,341
nonpt	242	All Restricted AADT	0	0	0	0	5,451
nonpt	244	All Unrestricted AADT	0	0	0	0	96,232
nonpt	271	NTAD Class 1 2 3 Railroad Density	0	0	0	0	2,252
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	20,531	184,856	208,027	64,947	104,310
nonpt	307	NLCD All Development	85	25,798	110,610	8,256	69,262
nonpt	308	NLCD Low + Med + High	1,029	172,195	16,762	13,578	9,849
nonpt	310	NLCD Total Agriculture	0	0	38	0	0
nonpt	319	NLCD Crop Land	0	0	95	71	293
nonpt	320	NLCD Forest Land	3,953	68	273	0	279
nonpt	650	Refineries and Tank Farms	0	16	0	0	106,401

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
nonpt	711	Airport Areas	0	0	0	0	621
nonpt	801	Port Areas	0	0	0	0	8,194
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	116
np_oilgas	671	Spud Count - Gas Wells	0	0	0	0	6,058
np_oilgas	674	Unconventional Well Completion Counts	20	17,955	452	20	844
np_oilgas	678	Completions at Gas Wells	0	5,397	136	2,980	31,452
np_oilgas	679	Completions at CBM Wells	0	5	0	198	804
np_oilgas	681	Spud Count - Oil Wells	0	0	0	0	15,200
np_oilgas	683	Produced Water at All Wells	0	0	0	0	941
np_oilgas	685	Completions at Oil Wells	0	262	0	889	30,398
np_oilgas	687	Feet Drilled at All Wells	0	43,122	1,229	54	2,213
np_oilgas	689	Gas Produced - Total	0	4,180	542	43	28,952
np_oilgas	691	Well Counts - CBM Wells	0	12,811	242	5	16,129
np_oilgas	694	Oil Production at Oil Wells	0	2,273	0	12,622	320,445
np_oilgas	695	Well Count - Oil Wells	0	113,355	2,548	601	482,308
np_oilgas	696	Gas Production at Gas Wells	0	1,841	0	17	258,236
np_oilgas	698	Well Count - Gas Wells	0	258,985	4,836	239	448,848
np_oilgas	699	Gas Production at CBM Wells	0	312	40	3	3,248
np_oilgas	2688	WRAP Gas production at oil wells	0	7,747	0	5,487	221,806
np_oilgas	2689	WRAP Gas production at all wells	0	26,613	782	1,133	22,687
np_oilgas	2691	WRAP Well count - CBM wells	0	512	41	7	2,027
np_oilgas	2693	WRAP Well count - all wells	0	8,376	110	20	3,345
np_oilgas	2694	WRAP Oil production at oil wells	0	35,144	543	18,367	110,299
np_oilgas	2695	WRAP Well count - oil wells	0	2,726	244	12	75,352
np_oilgas	2696	WRAP Gas production at gas wells	0	4,316	42	2	36,853
np_oilgas	2697	WRAP Oil production at gas wells	0	1,515	0	10	142,334
np_oilgas	2698	WRAP Well count - gas wells	0	4,672	306	14	98,613
np_oilgas	2699	WRAP Gas production at CBM wells	0	20,901	361	17	8,241
np_oilgas	6831	Produced water at CBM wells	0	0	0	0	972

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
np_oilgas	6832	Produced water at gas wells	0	0	0	0	12,662
np_oilgas	6833	Produced water at oil wells	0	0	0	0	12,596
onroad	205	Extended Idle Locations	316	36,205	829	17	4,417
onroad	242	All Restricted AADT	36,294	1,175,588	31,434	7,652	166,637
onroad	244	All Unrestricted AADT	66,408	1,816,651	62,438	16,561	453,336
onroad	259	Transit Bus Terminals	12	2,634	65	2	486
onroad	304	NLCD Open + Low		864	27	0	6,330
onroad	306	NLCD Med + High	859	95,627	4,718	85	22,369
onroad	307	NLCD All Development	3,768	238,117	6,279	1,547	620,852
onroad	308	NLCD Low + Med + High	230	25,884	536	94	35,391
onroad	508	Public Schools	15	2,397	126	2	688
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	16,943	35,204	309,019	8,249	334,217
solvents	100	Population	0	0	0	0	1,487,737
solvents	306	NLCD Med + High	0	0	0	0	744,921
solvents	307	NLCD All Development	0	0	0	0	401,086
solvents	310	NLCD Total Agriculture	0	0	0	0	180,552
solvents	676	Well Count - All Producing	0	0	0	0	27,701

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, 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 12-km and 36-km meteorology can introduce differences in onroad emissions, and 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: http://www3.epa.gov/scram001/reports/Emissions%20TSD%20Vol1_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 have been updated in the 2014v7.1 platform and carried forward into the 2016 platform. For the 2016 beta (v7.2) platform, a new set of Canada shapefiles were provided by Environment Canada along with cross references spatially allocate the year 2015 Canadian emissions. Gridded surrogates were generated using the Surrogate Tool (previously referenced); Table 3-25 provides a list. Due to 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
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

Code	Canadian Surrogate Description	Code	Description
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
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

Sector	Code	Mexican / Canadian Surrogate Description	NH_3	NO_X	PM_{2_5}	SO_2	VOC
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:

1) 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
2) Shift hourly emissions files from the 25 hour format used by CMAQ to the averaged 24 hour format used by CAMx
3) Rename and aggregate model species for CAMx
4) Convert 3D wildland and agricultural fire emissions into CAMx point format
5) Merge all inline point source emissions files together for each day, including layered fire emissions originally from SMOKE
6) Add sea salt aerosol emissions to the converted, gridded low-level emissions files

Conversion of file formats from I/O API to UAM (i.e., CAMx) 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. 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.

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
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

Tag	Emissions applied to tag
30	New Jersey
31	New Mexico
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

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, 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.

4 Development of Future Year Emissions

The emission inventories for future years of 2023, 2026 and 2032 have been developed using projection methods that are specific to the type of emissions source. Future emissions are projected from the 2016 base case either by running models to estimate future 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 future 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 project, the methods used to project those sectors to 2023, 2026 and 2032 are summarized in Table 4-1. For some sectors, emissions were only projected to 2028 or 2030 instead of 2032 due to the availability of data for projection factors and other factors.

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

Platform Sector: ***abbreviation***	**Description of Projection Methods for Future Year Inventories**
EGU units: ***ptegu***	The Integrated Planning Model (IPM) was run to create the future year EGU emissions. IPM outputs from the Summer 2021 version of the IPM platform were used (https://www.epa.gov/airmarkets/epas-power-sector-modeling-platform-v6-using-ipm-summer-2021-reference-case). For 2023, the 2023 IPM output year was used, for 2026 the 2025 output year was used, and for 2032 the 2030 output year was used because the year 2032 maps to the 2030 output year. 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 2019 using historic production data. The production-related sources were then grown to 2023, 2026 and 2032 based on growth factors derived from the Annual Energy Outlook (AEO) 2021 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 levels. WRAP future year inventories are used in the seven WRAP states (CO, MT, ND, NM, SD, UT and WY). The future year WRAP inventories are the same for all future years.
Airports: ***airports***	Point source airport emissions were grown from 2016 to each future year using factors derived from the 2019 Terminal Area Forecast (TAF) (see https://www.faa.gov/data_research/aviation/taf/). Corrections to emissions for ATL from the state of Georgia are included.

Platform Sector: *abbreviation*	Description of Projection Methods for Future Year Inventories
Remaining non-EGU point: ***ptnonipm***	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 AEO2021 and for limited cases AEO2020 to reflect growth from 2020 onward. Data from earlier AEOs were used to derive factors for 2016 through 2020. 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 fully implemented in 2016 except for North Carolina. Reductions due to consent decrees that had not been fully implemented by 2016 were also applied, along with 2016v1 comments received from S/L/T agencies. Controls are reflected for the regional haze program in Arizona. Changes to ethanol plants and biorefineries are included. In 2016v2, additional closures were implemented, new sources were added based on 2018NEI, and growth in MARAMA states was updated using MARAMA spreadsheets after incorporating AEO 2021 data. Where projections resulted in significantly different emissions from historic levels, some sources were held at 2017, 2018, or 2019 levels.
Category 1, 2 CMV: ***cmv_c1c2***	Category 1 and category 2 (C1C2) CMV emissions sources outside of California were projected to 2023, 2026, and 2030 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 The 2023 emissions are unchanged from 2016v1 and the 2026 emissions are equivalent to interpolating 2016v1 emissions between 2023 and 2028. For the 2032 case, factors were derived in the same way but taken only to 2030. 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. For 2032, a 2028->2030 trend based on US factors was applied on top of the ECCC-based 2016->2028 projections that differed by province.
Category 3 CMV: ***cmv_c3***	Category 3 (C3) CMV emissions were projected to 2023, 2026, and 2030 using an EPA report on projected bunker fuel demand that projects fuel consumption by region out to the year 2030. 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 the new bunker fuel demand growth rates for 2023, 2026, and 2030 to arrive at the final growth rates. Projections were taken only to 2030 (used for 2032) as it was the last year of data in the report. The 2023 emissions are unchanged from 2016v1 and the 2026 emissions are equivalent to interpolating 2016v1 emissions between 2023 and 2028. Projection factors for Canada for 2026 were based on ECCC-provided 2023 and 2028 data interpolated to 2026. For 2032, a 2028->2030 trend based on US factors was applied on top of the ECCC-based 2016->2028 projections that differed by province.

Platform Sector: *abbreviation*	Description of Projection Methods for Future Year Inventories
Locomotives: ***rail***	Passenger and freight were projected using separate factors. Freight emissions were computed for future years based on future year fuel use values for 2023 and 2026. Specifically, they were based on AEO2018 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. The 2023 emissions are unchanged from 2016v1 platform. The future year 2026 was interpolated from the 2016v1 future years of 2023 and 2028. The future year 2032 emissions are projected based on AEO2018 growth rates from 2026 to 2030.
Area fugitive dust: ***afdust, afdust_ak***	Paved road dust was grown to 2023, 2026, and 2032 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, except in the MARAMA region and NC where some factors were provided for categories other than paved roads. The projected emissions are reduced during modeling according to a transport fraction (newly computed for the beta platform) and a meteorology-based (precipitation and snow/ice cover) zero-out as they are for the base year.
Livestock: ***livestock***	Livestock were projected to 2023, 2026, and 2030 based on factors created from USDA National livestock inventory projections published in March 2019 (https://www.ers.usda.gov/publications/pub-details/?pubid=92599). The latest year available in the report was 2030.
Nonpoint source oil and gas: ***np_oilgas***	Production-related sources were grown starting from an average of 2014 and 2016 production data. Emissions were initially projected to 2019 using historical data and then grown to 2023, 2026 and 2032 based on factors generated from AEO2021 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. The future year WRAP inventories for are the same for all future years.
Residential Wood Combustion: ***rwc***	RWC emissions were projected from 2016 to 2023, 2026 and 2032 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 growth is held constant after 2026 in the tool for all sources except fireplaces. RWC emissions in California, Oregon, and Washington were held constant.
Solvents: ***solvents***	Solvents are based on a new method for 2016v2, while in 2016v1 these emissions part of nonpt. 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. Outside of the MARAMA region, 2032 projections are proportional to growth in human population to 2030. The MARAMA nonpt tool was used to project 2026 emissions to 2032 after updating the AEO-based factors to use AEO2021. OTC controls for solvents are applied.

Platform Sector: *abbreviation*	Description of Projection Methods for Future Year Inventories
Remaining nonpoint: ***nonpt***	Industrial emissions were grown according to factors derived from AEO2021 to reflect growth from 2020 onward. Data from earlier AEOs were used to derive factors for 2016 through 2020. 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 AEO2021. Factors provided by North Carolina and New Jersey were preserved. The 2026 emissions were projected to 2032. 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 to account for fuel sulfur rules in the mid-Atlantic and northeast. OTC controls for PFCs are included. In general, controls and projection methods are consistent with those used in 2016v1.
Nonroad: ***nonroad***	Outside California and Texas, the MOVES3 model was run to create nonroad emissions for 2023, 2026, and 2032. The fuels used are specific to the future year, but the meteorological data represented the year 2016. For California and Texas, existing 2016v1 emissions were retained for 2023, and 2026 emissions were interpolated from 2016v1 2023 and 2028. For 2032, California emissions were interpolated between the years 2028 and 2035, submitted by the state. For 2032, for Texas, 2026 was projected to 2032 using MOVES trends.
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. Projection from 2019 to 2023, 2026, and 2032 were done using factors derived from AEO2020 (for years 2019 to 2020) and AEO 2021 (for years 2020 to 2023 and 2023 to 2026 and 2032). Where S/Ls provided activity data for 2023, those data were used. To create the emission factors, MOVES3 was run for the years 2023, 2026, and 2032, with 2016 meteorological data and fuels, but with age distributions projected to represent future years, and the remaining inputs consistent with those used in 2017. The future year activity data and emission factors were then combined using SMOKE-MOVES to produce the 2023, 2026, and 2032 emissions. **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 with MOVES3-based data. CARB inventories for 2026 and 2032 were interpolated from existing CARB years.
Other Area Fugitive dust sources not from the NEI: ***othafdust***	Othafdust emissions for future 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, and 2032 projections were set to the 2016v1 2028 inventory values. 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 future years, including the same transport fraction as the base year and the meteorology-based (precipitation and snow/ice cover) zero-out.

Platform Sector: *abbreviation*	Description of Projection Methods for Future Year Inventories
Other point sources not from the NEI: ***othpt***	Canada emissions for future 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, and 2032 projections were set to 2028. Canada projections were applied by province-subclass where possible (i.e., where subclasses did not change from 2016v1 to 2016v2). 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 future years 2023, 2026, and 2028 (representing 2032) 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, 2026, and 2028 (used to represent 2032) using projection factors based on data provided by ECCC and applied by province, pollutant, and ECCC sub-class code.
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 future years based on province-subclass changes in the ECCC-provided data used for 2016v1. 2026 projection factors were interpolated from 2023 and 2028, and 2032 emissions were set to 2028 levels.
Other non-NEI nonpoint and nonroad: ***othar***	Future year Canada nonpoint inventories were provided by ECCC for 2016v1. For Canadian nonroad sources, factors were provided from which the future 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. For 2032, Canada nonroad and rail emissions were projected from 2026 to 2032 based on US trends, while 2028 emissions were used to represent 2032 for the rest of the sector. 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, and 2028 emissions were used to represent 2032 in Mexico.
Other non-NEI onroad sources: ***onroad_can***	For Canadian mobile onroad sources, future 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. 2032 was projected from 2026 using US-based onroad trends.
Other non-NEI onroad sources: ***onroad_mex***	Monthly year Mexico (municipio resolution) onroad mobile inventories were developed based runs of MOVES-Mexico for 2023, 2028, and 2035. 2023 was reused from the 2016v1 platform; 2026 was interpolated between 2023 and 2028 and 2032 was interpolated between 2028 and 2035.

4.1 EGU Point Source Projections (ptegu)

The 2023, 2026, and 2032 EGU emissions inventories were developed from the output of the v6 platform using the Summer 2021 Reference Case run 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:

- 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 regulation requires states to submit revised State Implementation Plans (SIPs) that include (1) goals for improving visibility in Class I areas on the 20% worst days and allowing no degradation on the 20% best days and (2) assessments and plans for achieving Best Available Retrofit Technology (BART) emission targets for sources placed in operation between 1962 and 1977. Since 2010, EPA has approved SIPs or, in a few cases, put in place regional haze Federal Implementation Plans for several states. The BART limits approved in these plans (as of summer 2020) that will be in place for EGUs are represented in the 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 the 2023, 2025 (used for the 2026 case), and 2030 (used for the 2032 case[31]). All inputs, outputs and full documentation of EPA's IPM v6 Summer 2021 Reference Case and the associated NEEDS version is available on the power sector modeling website (https://www.epa.gov/airmarkets/documentation-epas-power-sector-modeling-platform-v6-summer-2021-reference-case). Some of the key parameters used in the IPM run are:

[31] Planned retirements for 2030 and 2031are adjusted so that 2030 outputs are reflective of the 2032 calendar year.

- Demand: AEO 2020
- Gas and Coal Market assumptions: updated as of September 2020
- 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
- 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 2021 reference case NEEDS

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 future 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. Additionally, some units, such as landfill gas, may not be assigned a valid SCC in the initial flat file. The SCCs for these units are updated based on the base year SCC for the unit-fuel type.

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 are updated with the parameters from the combustion release point.

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 future years.

The EGU sector NO_x emissions by state are listed in Table 4-2 for each of the 2016v2 cases.

Table 4-2. EGU sector NOx emissions by State for 2016v2 cases

State	2016fj	2023fj	2026fj	2032fj
Alabama	28,596	8,043	9,319	9,726
Arizona	21,716	3,806	3,416	5,817
Arkansas	27,224	10,014	9,258	11,583
California	7,123	14,292	16,286	12,885
Colorado	30,152	12,437	12,725	14,268
Connecticut	4,088	3,798	3,740	3,883
Delaware	1,487	311	320	464
District of Columbia	NA	38	39	39
Florida	64,682	22,004	22,451	21,423
Georgia	29,479	6,388	5,937	9,056
Idaho	1,369	738	705	737
Illinois	32,140	17,861	16,777	21,755
Indiana	83,485	37,165	36,007	35,951
Iowa	22,971	21,736	17,946	22,293
Kansas	14,959	3,824	4,351	8,115
Kentucky	57,583	25,679	25,207	22,992
Louisiana	48,021	15,888	16,949	18,053
Maine	4,935	3,743	3,063	3,171
Maryland	10,448	3,025	3,008	2,824
Massachusetts	8,605	4,625	4,566	4,652
Michigan	43,291	24,603	22,378	25,355
Minnesota	21,737	14,360	9,442	11,155
Mississippi	16,525	4,508	5,208	4,972
Missouri	57,647	40,766	34,935	44,534
Montana	15,832	8,796	8,760	9,060
Nebraska	20,738	24,712	20,274	22,011
Nevada	3,969	3,049	3,017	3,081
New Hampshire	2,158	507	483	547
New Jersey	6,626	3,915	4,032	4,052
New Mexico	20,222	1,834	1,987	1,417
New York	18,415	12,097	11,693	11,129
North Carolina	35,326	19,002	15,984	22,560
North Dakota	38,400	20,787	19,276	22,895
Ohio	55,581	33,865	27,031	34,326

State	2016fj	2023fj	2026fj	2032fj
Oklahoma	25,084	3,814	3,426	5,745
Oregon	4,150	2,194	2,145	4,129
Pennsylvania	84,086	20,793	23,965	22,131
Rhode Island	524	490	476	508
South Carolina	14,231	10,512	7,134	8,808
South Dakota	1,109	1,090	1,054	1,152
Tennessee	19,173	2,474	2,100	1,957
Texas	111,612	46,370	27,164	39,437
Tribal Data	35,057	2,940	2,970	5,637
Utah	27,450	20,588	10,915	16,478
Vermont	302	111	4	8
Virginia	27,953	6,431	7,270	6,554
Washington	8,860	2,319	2,532	2,848
West Virginia	52,265	29,445	21,450	23,343
Wisconsin	16,250	6,102	4,304	6,678
Wyoming	36,095	10,855	11,036	12,507

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 future 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 future-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 future year emissions are provided with other 2016v2 input data and reports on the 2016v2 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 future year inventories for the following sectors: afdust, airports, cmv, livestock, nonpt, np_oilgas, pt_oilgas, ptnonipm, rail, rwc, and solvents. 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 future year (i.e., projected) inventories. Future 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:

1. 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.
2. 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.
3. 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, inventory controls are first backed out prior to the application of a more-stringent replacement control).

These packets are stored as data sets within the Emissions Modeling Framework and use comma-delimited formats. 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 future-year emissions value. Therefore, as encountered with this future year base case, consent decrees and state comments for specific cement kilns (expressed as CONTROL packet entries) needed 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, although the fields in the table are not necessarily named the same in CoST, but rather are similar to those 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
17	NAICS, SCC, POLL	point, nonpoint
18	NAICS, POLL	point, nonpoint

Rank	Matching Hierarchy	Inventory Type
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 future 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 several subsections that are summarized in Table 4-4. Note that independent future 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 future 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.
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.

Subsection	Title	Sector(s)	Brief Description
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 AEO2020 and AEO2021 were used for nonpt and ptnonipm. Data derived from EIA state historical data and AEO2021 for 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, EIA-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 EIA-based factors for industrial sources. Evaporative Emissions from Finished Fuels projected using EIA-based factors. Human population used as growth for applicable sources.
4.2.3.9	Solvents	solvents	Several PROJECTION packets including population-based, MARAMA state factors, and oil
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 future 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	CISWI	ptnonipm	CONTROL packet: applies controls to specific CISWI units in 11 states.
4.2.4.7	Petroleum Refineries NSPS Subpart JA	ptnonipm	CONTROL packet: control efficiencies are applied to identified delayed coking and storage tank units.

Subsection	Title	Sector(s)	Brief Description
4.2.4.89	Ozone Transport Commission Rules	nonpt, solvents	CONTROL packets reflecting rules for solvents and portable fuel containers.
4.2.4.8	State-Specific Controls	ptnonipm	CONTROL packets and comments submitted by individual states for rules that may only impact their state or corrections noted from previous reviews. Includes consent decrees and Arizona regional haze controls.

4.2.2 CoST Plant CLOSURE Packet (ptnonipm, pt_oilgas)

Packets:

CLOSURES_2016v2_platform_ptnonipm_18jun2021_v2

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). In addition, comments on past modeling platforms received by states and other agencies specified additional closures, as well as some previously specified closures which should remain open, in the following states: Alabama, North Carolina, Ohio, Pennsylvania, and Virginia. The list of closures also includes two Pennsylvania facilities that were only partially closed in prior runs, but have since completely closed: Pittsburgh Corning Corp – Port Allegany (ID 3025211), and Osram Sylvania Inc. – Wellsboro Plant (ID 5490611). Ultimately, all data 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. The cumulative reduction in emissions for ptnonipm and pt_oilgas are shown in Table 4-5.

Table 4-5. Reductions from all facility/unit/stack-level closures in 2016v2

Pollutant	Ptnonipm	pt_oilgas
CO	12,147	187
NH3	508	0
NOX	14,009	284
PM10	10,891	9
PM2.5	7,104	9
SO2	24,103	178
VOC	7,181	106

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

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 future 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 only provided pt_oilgas and np_oilgas packets for Rhode Island, Maryland and Massachusetts. For 2016v2, new spreadsheets of projection factors were provided that facilitated the incorporation of data from the AEO 2021 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_version1_platform_national_24jun2021_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_version1_platform_national_20jul2021_v0
Projection_2016_2026_all_nonpoint_version1_platform_NC_19jul2021_v0
Projection_2026_2032_afdust_version2_platform_MARAMA_nopavedroads_05aug2021_v0
Projection_2026_2032_afdust_version2_platform_national_05aug2021_v0

MARAMA States

MARAMA provided a spreadsheet tool that could be used to compute projection factors for their states to project 2016 afdust emissions to future years 2023, 2026, and 2032. 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 future year projections. North Carolina and New Jersey provided their own packets for this sector for 2023 and 2028, which were interpolated to 2026. Projections for 2032 used a 2026 baseline and were based on MARAMA-provided data, including in NC and NJ. For paved roads, new VMT-based projection factors based on 2016v2 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 future years 2023 and 2026 based on differences in county total VMT:

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

EPA used a similar method to develop factors to project the afdust emissions from 2026 to 2032. 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 future 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 2016v2

2016 Emissions	2023 Emissions	percent Increase 2023	2026 Emissions	percent Increase 2026	2032 Emissions	percent Increase 2032
2,254,168	2,313,089	2.61%	2,332,376	3.47%	2,353,763	4.42%

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_version2_platform_23jun2021_v0
Projection_2017_2023_ag_version1_platform_NJ_20aug2021_v1
Projection_2017_2026_ag_livestock_version2_platform_23jun2021_v0
Projection_2017_2026_livestock_version2_platform_NJ_16jul2021_v0
Projection_2026_2032_ag_livestock_version2_platform_05aug2021_v0

The 2017NEI livestock emissions were projected to year 2023 and 2028 using projection factors created from USDA National livestock inventory projections published in March 2019 (https://www.ers.usda.gov/publications/pub-details/?pubid=92599) 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 and 2030, the same method was used to develop and apply the factors. Note that 2030 is the latest year available in this report so the projection inventory used in the 2032 case was for 2030 for this sector. 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 back-casted base year emissions to 2023 and 2026. As in New Jersey, North Carolina provided projection factors for 2023 and 2028, which were interpolated to 2026.

The EPA developed factors using the USDA data to project livestock emissions from 2026 to 2030 and applied these in all states.

Table 4-7. National projection factors for livestock: 2017 to 2023, 2026, and 2030

Animal	2017-to-2023	2017-to-2026	2017-to-2030
beef	-0.27%	+0.61%	+1.51%
swine	+8.93%	+12.50%	+15.17%
broilers	+8.30%	+12.67%	+18.77%
turkeys	+1.22%	+2.52%	+4.29%
layers	+6.88%	+12.60%	+20.22%
dairy	+0.62%	+1.28%	+2.16%

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
Projection_2016_2030_cmv_c1c2_version2_platform_04aug2021_v0
Projection_2016_2030_cmv_Canada_version2_platform_04aug2021_v0

Category 1 and category 2 (C1C2) CMV emissions sources outside of California were projected to 2023, 2026, and 2030 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 emissions are unchanged from 2016v1 and the 2026 emissions are equivalent to interpolating 2016v1 emissions between 2023 and 2028. Projections were taken only to 2030 and those were used for the 2032 case. 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. For 2032, a 2028 to 2030 trend based on US factors was applied on top of the ECCC-based 2016 to 2028 projections that differed by province

Table 4-8. National projection factors for cmv_c1c2

Pollutant	2016-to-2023 (%)	2016-to-2026 (%)	2016-to-2030 (%)
CO	-1.3%	-0.4%	+1.4%
NOX	-29.3%	-39.0%	-49.3%
PM10	-28.3%	-37.8%	-48.3%
PM2.5	-28.3%	-37.8%	-48.3%
SO2	-65.3%	-65.7%	-66.1%
VOC	-31.5%	-42.0%	-51.3%

Table 4-9. California projection factors for cmv_c1c2

Pollutant	2016-to-2023 (%)	2016-to-2026 (%)	2016-to-2030 (%)
CO	+20.1%	+23.2%	+26.5%
NOX	-15.0%	-16.6%	-19.4%
PM10	-29.9%	-32.1%	-35.8%
PM2.5	-29.9%	-32.1%	-35.8%
SO2	+24.1%	+38.9%	+61.0%
VOC	+1.5%	+1.7%	+0.5%

4.2.3.4 Category 3 Commercial Marine Vessels (cmv_c3)

Packets:

Projection_2016_2023_cmv_c3_version1_platform_04oct2019_v2_Mexico[32]
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
Projection_2016_2030_cmv_c3_version2_platform_04aug2021_v0
Projection_2016_2030_cmv_Canada_version2_platform_04aug2021_v0

Growth rates for cmv_c3 emissions from 2016 to 2023, 2026 and 2030 were projected using an EPA report on projected bunker fuel demand. Bunker fuel usage was used as a surrogate for marine vessel activity. The report projects bunker fuel consumption by region out to the year 2030. 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 year 2030 was used for 2032 due to uncertainty in future fuel use data.

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)[33] 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, 2026, and 2030 to arrive at the final growth rates. Projections were taken only to 2030 (used for 2032) as it was the last year of data in the report. 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 emissions are unchanged from 2016v1 and the 2026 emissions are equivalent to interpolating 2016v1 emissions between 2023 and 2028. Projection factors for Canada for 2026 were based on ECCC-provided 2023 and 2028 data interpolated to 2026. For 2032, a 2028 to 2030 trend based on US factors was applied on top of the ECCC-based 2016 to 2028 projections that differed by province.

[32] 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.

[33] https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1005ZGH.TXT.

The 2023, 2026, and 2030 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

Table 4-10. 2016-to-2023, 2016-to-2026, and 2016-to-2030 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	2016-to-2030 NOX	2016-to-2030 other pollutants
US East Coast	-6.1%	+27.7%	-6.9%	+41.4%	-8.1%	+58.4%
US South Pacific (ex. California)	-24.8%	+20.9%	-30.3%	+36.6%	-37.6%	+55.2%
US North Pacific	-3.4%	+22.6%	-3.8%	+34.6%	-4.4%	+47.8%
US Gulf	-6.9%	+20.8%	-10.2%	+29.8%	-14.6%	+42.5%
US Great Lakes	+8.7%	+14.6%	+15.4%	+22.7%	+24.2%	+33.9%
Other	+23.1%	+23.1%	+35.0%	+35.0%	+50.1%	+50.1%

Non-Federal Waters	2016-to-2023	2016-to-2026	2016-to-2030
SO2	-77.2%	-75.0%	-72.2%
PM (main engines)	-36.1%	-29.9%	-22.0%
PM (aux. engines)	-39.7%	-33.9%	-26.5%
Other pollutants	+23.1%	+35.0%	+50.1%

Table 4-11. 2016-to-2023, 2016-to-2026, and 2016-to-2030 CMV C3 projection factors for California

Pollutant	2016-to-2023	2016-to-2026	2016-to-2030
CO	1.180	1.276	1.401
Nox	1.156	1.259	1.336
PM_{10} / $PM_{2.5}$	1.205	1.311	1.447
SO_2	1.183	1.272	1.392
VOC	1.242	1.373	1.542

4.2.3.5 Oil and Gas Sources (pt_oilgas, np_oilgas)

Packets:

Projection_2016_2023_oilgas_version2_platform_30jun2021_v1
Projection_2016_2026_oilgas_version2_platform_14jul2021_v0
Projection_2016_2032_oilgas_version2_platform_14jul2021_v0

Future year inventories for seven of the WRAP states were provided by WRAP. 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). This future year WRAP data for np_oilgas and pt_oilgas are the same for all future years, 2023 = 2026 = 2032.

For areas outside of the WRAP states, future year projections for the 2016v2 platform were generated for point oil and gas sources for years 2023, 2026 and 2032. 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 future-year emissions before applicable control technologies are applied using the CoST PROJECTION packet; and (3) estimating impacts of applicable control technologies on future-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 inTable 4-5. Note the closures for years 2023, 2026 and 2032 are the same.

For pt_oilgas growth to 2023, 2026 and 2032, the oil and gas sources were separated into production-related and exploration-related sources by SCC. These sources were further subdivided by fuel-type by SCC into either OIL, natural gas (NGAS), BOTH oil-natural gas fuels possible, or coal-bed methane (CBM). The next two subsections describe the growth component process.

For np_oilgas growth to 2023, 2026 and 2032, oil and gas sources were separated into production-related, transmission-related, and all other point sources by NAICS. These sources are further subdivided by fuel-type by SCC into either OIL, natural gas (NGAS), or BOTH oil-natural gas fuels possible.

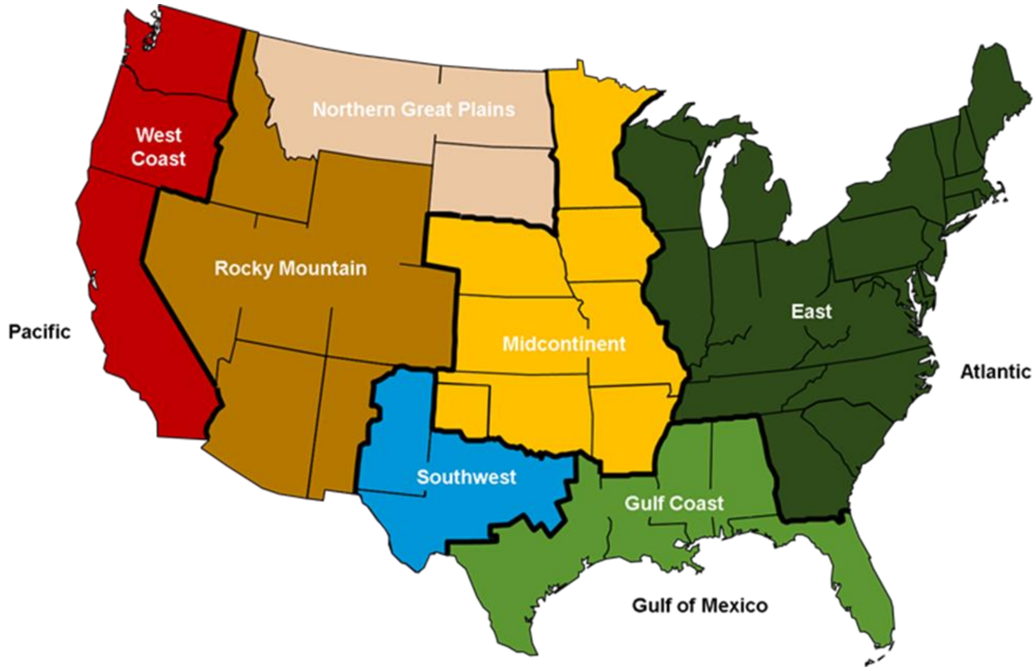
Production-related Sources (pt_oilgas, np_oilgas)

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 2019.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) 2021 reference case for the Lower 48 forecast production tables to project from year 2019 to the years of 2023 and 2028. Specifically, *AEO 2021 Table 59 "Lower 48 Crude Oil Production and Wellhead Prices by Supply Region"* and *AEO 2021 Table 60 "Lower 48 Natural Gas Production and Supply Prices by Supply Region"* were used in this projection process. The AEO2021 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 AEO2021



The result of this second step is a growth factor for each Supply Region from 2019 to 2023 and from 2019 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 (2016 to 2019) was then multiplied by the Supply Region factor (2019 to future 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 technical direction for growth of production-related point sources. Texas provided updated basin specific production for 2016 and 2019 to allow for a better calculation of the estimated growth for this three-year period (http://webapps.rrc.texas.gov/PDQ/generalReportAction.do). The AEO2021 was used as described above for the three AEO Oil and Gas Supply Regions that include Texas counties to grow from 2019 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.

After the 2023 run, it was discovered that Texas CBM emissions in "no growth" counties were incorrectly grown (reduced by 19%) in 2023. This was fixed for 2026 and 2032. Texas gas and oil emissions in "no growth" counties were correctly held flat (plus controls if applicable) in 2023.

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.state.nm.us/ocd/ocdpermitting/Reporting/Production/CountyProductionInjectionSummary.aspx) so that a better estimate of growth from 2016 to 2019 for the AEO Supply Regions in New Mexico could be calculated.

Transmission-related Sources (pt_oilgas)

Projection factors were generated using the same AEO2021 tables used for production sources. The growth factors for transmission sources were developed solely using AEO 2021 data for the entire lower 48 states (one national factor for oil transmission and one national factor for natural gas transmission).

Exploration-related Sources (np_oilgas)

Due to Year 2016 being a low exploration activity year when compared to exploration activity in other recent years, Years 2014 through 2017 exploration emissions were generated using the 2017NEI version of the Oil and Gas Tool. Table 4-12provides a high-level national summary of the activity data for the four years. This four-year average (2014-2017) emissions data were used because they were readily available for use with the 2016v2 platform. These averaged emissions were used for both the 2023, 2026 and 2032 future years in the 2016v2 emissions modeling platform. Note CoST was not used for this projection step for exploration sources.

Table 4-12. Year 2014-2017 high-level summary of national oil and gas exploration activity

Parameter (all US states)	Year2014	Year2015	Year2016	Year2017	4-year average
Total Well Completions	40,306	22,754	15,605	21,850	25,129
Unconventional Well Completions	20,896	11,673	7,610	11,617	12,949
Total Oil Spuds	36,104	17,240	7,014	14,322	18,670
Total Natural Gas Spuds	4,750	3,168	4,244	4,025	4,047
Total Coalbed Methane Spuds	239	130	141	222	183
Total Spuds	41,093	20,538	11,399	18,569	22,900
Total Feet Drilled	327,832,580	178,297,779	106,468,774	181,164,800	198,440,983

Projection overrides (pt_oilgas)

A draft set of projected point oil and gas emissions were reviewed and compared to recent emissions data from 2018. 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 future years. The affected sources are shown in Table 4-13.

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

County FIPS	State	County	Facility ID	Facility Name
01091	Alabama	Marengo Co	1041811	Transcontinental Gas Pipe Line Company L
01129	Alabama	Washington Co	1028711	American Midstream Chatom, LLC
04005	Arizona	Coconino Co	1115011	EPNG - WILLIAMS COMPRESSOR STATION
13195	Georgia	Madison Co	2803411	Transcontinental Gas Pipe Line Company,

County FIPS	State	County	Facility ID	Facility Name
18003	Indiana	Allen Co	4544011	PANHANDLE EASTERN PIPE LINE CO EDGERT
18075	Indiana	Jay Co	7957111	ANR PIPELINE COMPANY PORTLAND COMPRES
19181	Iowa	Warren Co	2962011	NATURAL GAS PIPELINE CO OF AMERICA - STA
20057	Kansas	Ford Co	3839911	Natural Gas Pipeline of America – Minneo
20097	Kansas	Kiowa Co	5027511	Northern Natural Gas - Mullinville Stati
21089	Kentucky	Greenup Co	6096911	TN Gas Pipeline Co LLC - Station 200
21197	Kentucky	Powell Co	5787411	TN Gas Pipeline Co LLC - Station 106
21217	Kentucky	Taylor Co	5727111	TN Gas Pipeline Co LLC - Station 871
22001	Louisiana	Acadia Par	6082411	ANR Pipeline Co - Eunice Compressor Stat
22011	Louisiana	Beauregard Par	5998611	Transcontinental Gas Pipe Line Co LLC (T
22013	Louisiana	Bienville Par	6000211	Southern Natural Gas Co - Bear Creek Sto
22021	Louisiana	Caldwell Par	6426511	Texas Gas Transmission LLC - Columbia Co
22023	Louisiana	Cameron Par	13610511	Sabine Pass LNG LP - Sabine Pass Liquefa
22075	Louisiana	Plaquemines Par	7449511	East Bay Central Facility
22079	Louisiana	Rapides Par	5740911	Texas Gas Transmission LLC - Pineville C
22083	Louisiana	Richland Par	5607811	ANR Pipeline Co - Delhi Compressor Stati
22113	Louisiana	Vermilion Par	5064311	Sea Robin Pipeline Co LLC - Erath Compre
28063	Mississippi	Jefferson Co	7035611	Texas Eastern Transmission LP, Union Chu
28067	Mississippi	Jones Co	7035911	TRANSCONTINENTAL GAS PIPE LINE COMPANY L
28137	Mississippi	Tate Co	6952811	Trunkline Gas Company, LLC, Independence
31131	Nebraska	Otoe Co	7767611	Northern Natural Gas Company
39039	Ohio	Defiance Co	7938111	ANR Pipeline Company (0320010169)
39045	Ohio	Fairfield Co	8259811	CRAWFORD COMPRESSOR STATION (0123000137)
40007	Oklahoma	Beaver Co	8131911	BEAVER COMPRESSOR STATION
40139	Oklahoma	Texas Co	8402511	TYRONE CMPSR STA
48103	Texas	Crane Co	4163111	BLOCK 31 GAS PLANT
48195	Texas	Hansford Co	6534211	EG HILL COMPRESSOR
48371	Texas	Pecos Co	5765911	COYANOSA GAS PLANT
48501	Texas	Yoakum Co	6648711	PLAINS COMPRESSOR STATION
51143	Virginia	Pittsylvania Co	4005411	Transco Gas Pipe Line Corp Station 165
54083	West Virginia	Randolph Co	6790711	Columbia Gas - FILES CREEK 6C4340
54099	West Virginia	Wayne Co	6341411	Columbia Gas - CEREDO 4C3360

4.2.3.6 Non-EGU point sources (ptnonipm)

Packets:

Projection_2016_202X_ptnonipm_version1_platform_WI_supplement_25sep2019_v0
Projection_2016_2023_corn_ethanol_E0B0_Volpe_27sep2019_v0
Projection_2016_2023_finished_fuels_volpe_04oct2019_v2
Projection_2016_2023_industrial_byNAICS_SCC_version2_platform_23jun2021_v0
Projection_2016_2023_industrial_bySCC_version2_platform_28jun2021_nf_v1
Projection_2016_2023_ptnonipm_airports_railyards_version1_platform_NC_nopoll_26sep2019_v0
Projection_2016_2023_ptnonipm_version2_platform_MARAMA_20aug2021_v1
Projection_2016_2023_ptnonipm_version1_platform_NJ_10sep2019_v0
Projection_2016_2023_ptnonipm_version1_platform_VA_04oct2019_v1
Projection_2023_2026_finished_fuels_volpe_16jul2021_v0
Projection_2023_2026_industrial_byNAICS_SCC_version2_platform_23jul2021_v0
Projection_2023_2026_industrial_bySCC_version2_platform_23jul2021_nf_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
projection_2026_2028_corn_ethanol_E0B0_Volpe_13aug2021_v0
Projection_2026_2028_finished_fuels_volpe_13aug2021_v0
Projection_2026_2032_industrial_byNAICS_SCC_version2_platform_13aug2021_v0
Projection_2026_2032_industrial_bySCC_version2_platform_13aug2021_nf_v1
Projection_2026_2032_ptnonipm_version2_platform_MARAMA_13aug2021_v0

The 2023, 2026, and 2032 ptnonipm projections 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

2016-to-2023 and 2016-to-2026 projection packets for point sources were provided by MARAMA for the following states: CT, DE, DC, ME, MD, MA, NH, NJ, NY, NC, PA, RI, VT, VA, and WV.

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 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 a Pennsylvania source (process ID 13629614) based on updated information provided by MARAMA.

2023 and 2026 Point Inventories - outside MARAMA region

Projection factors were developed by industrial sector from 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; and either AEO2020 or AEO2021 to go from 2020 to 2023 and 2026. AEO2020 was used for Process Flow categories – paper, aluminum, glass, cement/lime, iron/steel – due to reported issues with AEO2021 that affected these categories. All other source categories used AEO2021. 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 AEO2021 tables 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 1.25. MARAMA states were not projected using this method. Also in 2016v2, 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 AEO2021. SCC/NAICS combinations with emissions >100tons/year for any CAP[34] were mapped to AEO sector and fuel. Projection factors for this method were capped at a maximum of 2.5.

New units were added for 2016v2 based on 2018NEI analysis, although these are also added in 2016 as described in Section 2.1.3.

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) 2021 tables used to project industrial sources

AEO 2021 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

The state of Wisconsin provided source-specific growth factors for four facilities in the state. For those facilities, the growth factors provided by Wisconsin were used instead of those derived from the AEO.

A draft set of projected ptnonipm emissions were reviewed and compared to recent emissions data from 2017 through 2019. In cases where the recent and projected emissions were substantially different, the 2023 emissions were instead taken from a recent year of emissions and were then projected from 2023 to later future years. The affected sources are shown in Table 4-15.

[34] The "100 tpy" criterion for this purpose was based on emissions in the emissions values in the 2016 beta platform.

Table 4-15. Ptnonipm sources held at recent emission levels

County FIPS	State	County	Facility ID	Facility Name	Override year
01053	AL	Escambia Co	7440111	Georgia-Pacific Brewton LLC	2018
01097	AL	Mobile Co	1060511	Kimberly-Clark Corporation	2018
01099	AL	Monroe Co	1019211	GP Cellulose Alabama River Cellulose LLC	2018
01099	AL	Monroe Co	1019211	GP Cellulose Alabama River Cellulose LLC	2018
04013	AZ	Maricopa Co	1121211	Oak Canyon Manufacturing Inc	2017
05063	AR	Independence Co	1082811	FUTUREFUEL CHEMICAL COMPANY	2018
06037	CA	Los Angeles Co	15995211	ROBERTSONS READY MIX - PALMDALE	2018
06071	CA	San Bernardino Co	706411	NTC - DIR. OF PUBLIC WORKS, MISSION RELA	2018
06071	CA	San Bernardino Co	706411	NTC - DIR. OF PUBLIC WORKS, MISSION RELA	2018
06083	CA	Santa Barbara Co	7064311	IMERYS FILTRATION MINERALS, INC.	2018
08069	CO	Larimer Co	4363211	AVAGO TECHNOLOGIES WIRELESS (USA) MANUF.	2018
12057	FL	Hillsborough Co	716311	MOSAIC FERTILIZER, LLC	2017
12105	FL	Polk Co	535211	CITROSUCO NORTH AMERICA, INC.	2018
13021	GA	Bibb Co	7414811	Graphic Packaging Macon Mill	2018
13067	GA	Cobb Co	554511	Caraustar Industries Inc	2018
13095	GA	Dougherty Co	3709811	MillerCoors LLC	2018
13103	GA	Effingham Co	536311	Georgia-Pacific Consumer Operations LLC	2018
13185	GA	Lowndes Co	555311	PCA Valdosta Mill	2018
13193	GA	Macon Co	8352311	International Paper - Flint River Mill	2018
13245	GA	Richmond Co	554311	DSM Chemicals North America, Inc.	2018
17031	IL	Cook Co	3205411	Bimbo QSR Chicago LLC	2017
17103	IL	Lee Co	7792411	St. Marys Cement Inc	2018
17103	IL	Lee Co	7792411	St. Marys Cement Inc	2018
17103	IL	Lee Co	7792411	St. Marys Cement Inc	2018
18165	IN	Vermillion Co	8223611	Elanco US Incorporated Clinton Laborato	2018
20209	KS	Wyandotte Co	15089511	Reconserve Inc.	2017
21019	KY	Boyd Co	5060111	Ak Steel Corp	2018
21019	KY	Boyd Co	5060111	Ak Steel Corp	2018
21019	KY	Boyd Co	5060111	Ak Steel Corp	2018
21059	KY	Daviess Co	5892411	Owensboro Grain Co	2018
21145	KY	Mc Cracken Co	6050611	Four Rivers Nuclear Partnership LLC - Pa	2018
21205	KY	Rowan Co	7382011	Guardian Automotive Trim, SRG Global Inc	2017
22033	LA	East Baton Rouge Par	7228811	ExxonMobil Chemical Company - Baton Roug	2018
22033	LA	East Baton Rouge Par	8214811	Georgia-Pacific Consumer Operations LLC	2019

County FIPS	State	County	Facility ID	Facility Name	Override year
22089	LA	St Charles Par	8020911	Rain CII Carbon LLC - Norco Coke Calcini	2018
22093	LA	St James Par	5273111	Rain CII Carbon LLC - Gramercy Coke Plan	2018
22093	LA	St James Par	7205911	Mosaic Fertilizer LLC - Faustina Plant	2018
26103	MI	Marquette Co	17688311	Marquette Branch Prison	2018
26115	MI	Monroe Co	7888111	Guardian Industries-Carleton	2018
26125	MI	Oakland Co	6664511	EAGLE VALLEY RECYCLE AND DISPOSAL FACILI	2018
26147	MI	St Clair Co	7239111	ST. CLAIR / BELLE RIVER POWER PLANT	2018
28131	MS	Stone Co	15334111	MF WIGGINS LLC	2018
36001	NY	Albany Co	8105211	LAFARGE BUILDING MATERIALS INC	2018
36089	NY	St. Lawrence Co	7968211	ALCOA MASSENA OPERATIONS (WEST PLANT)	2018
36089	NY	St. Lawrence Co	17890211	ALCOA USA Corp	2018
37027	NC	Caldwell Co	7961211	Hamilton Square Lenoir Casegoods Plant	2018
37049	NC	Craven Co	8504911	Marine Corps Air Station - Cherry Point	2018
37049	NC	Craven Co	8504911	Marine Corps Air Station - Cherry Point	2018
37133	NC	Onslow Co	8424011	MCIEAST-Marine Corps Base Camp Lejeune	2018
41029	OR	Jackson Co	8056111	Roseburg Forest Products - Medford MDF	2018
41029	OR	Jackson Co	8056211	Biomass One, L.P.	2018
42007	PA	Beaver Co	8141411	ALLEGHENY & TSINGSHAN STAINLESS LLC MIDL	2018
42007	PA	Beaver Co	8141411	ALLEGHENY & TSINGSHAN STAINLESS LLC MIDL	2018
42071	PA	Lancaster Co	4951311	BUCK CO INC/QUARRYVILLE	2018
45035	SC	Dorchester Co	4797811	SHOWA DENKO CARBON INC	2018
47037	TN	Davidson Co	4700711	Vanderbilt University	2017
47157	TN	Shelby Co	5723011	Cargill Corn Milling	2018
48057	TX	Calhoun Co	5846711	POINT COMFORT PLANT	2018
51085	VA	Hanover Co	6310111	Bear Island Paper Company	2017
51085	VA	Hanover Co	6310111	Bear Island Paper Company	2018
51121	VA	Montgomery Co	5748611	Radford Army Ammunition Plant	2019
51680	VA	Lynchburg	6648111	Griffin Pipe Products Company LLC	2018
51700	VA	Newport News	4938811	Huntington Ingalls Incorporated -NN Ship	2018
53011	WA	Clark Co	4986811	Georgia-Pacific Consumer Operations LLC	2018
54039	WV	Kanawha Co	5782411	BAYER CROPSCIENCE - Institute	2018
55009	WI	Brown Co	4943911	Ahlstrom-Munksjo NA Specialty Solutions	2018
55031	WI	Douglas Co	4864411	Superior Refining Company LLC	2018
55133	WI	Waukesha Co	12694411	PROHEALTH CARE WAUKESHA MEMORIAL	2018

2032 Point Inventories

The 2032 point inventory was created by projecting 2026 to 2032 to simplify the procedure and to keep these factors consistent throughout the platform.

All Volpe packets stopped at 2028 because that was the last year available.

The MARAMA and PFC projection packets were developed from the MARAMA tool including updated AEO values and VMT to get the factors from 2026 to 2032.

A new 2026 to 2032 projection packet was created based on human population. The human population dataset does not contain population estimates beyond 2030, to 2030 population was used to represent 2032. A new 2026 to 2032 projection packet was created for industrial sources based on AEO2021.

Rail yards were projected from 2026 to 2032 based on AEO 2021 using the same factors as were used for the rail sector class II and III commuter trains.

4.2.3.7 Airport sources (airports)

Packets:

airport_projections_itn_taf2019_2016_2023_04jun2021_v0
airport_projections_itn_taf2019_2016_2026_04jun2021_v0
airport_projections_itn_taf2019_2016_2032_04jun2021_v0

Airport emissions were projected from the 2016 airport emissions based on the corrected 2017 NEI airport emissions to 2023, 2026, and 2032, using the same projection approach as for 2016v1, but using TAF 2019 instead of TAF 2018, and starting from the base year 2016 instead of 2017. The Terminal Area Forecast (TAF) data available from the Federal Aviation Administration (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. For airports not matching a unit in the TAF data, state default growth factors by itinerant class (commercial, air taxi, and general) were created from the collection of airports unmatched. Emission growth for facilities is capped at 500% and the state default growth is 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_24jun2021_nf_v5
Projection_2016_2023_finished_fuels_volpe_04oct2019_v2
Projection_2016_2023_industrial_bySCC_version2_platform_28jun2021_nf_v1
Projection_2016_2023_nonpt_other_version2_platform_MARAMA_02jul2021_nf_v1
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_19jul2021_nf_v1
Projection_2016_2026_finished_fuels_volpe_16jul2021_v0
Projection_2016_2026_industrial_bySCC_version2_platform_16jul2021_v1
Projection_2016_2026_nonpt_other_version2_platform_MARAMA_noNCNJ_16jul2021_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
Projection_2026_2028_finished_fuels_volpe_13aug2021_v0
Projection_2026_2030_nonpt_population_version2_platform_noMARAMA_05aug2021_v0
Projection_2026_2032_industrial_bySCC_version2_platform_13aug2021_nf_v1
Projection_2026_2032_nonpt_other_version2_platform_MARAMA_05aug2021_v0
Projection_2026_2032_nonpt_PFC_version2_platform_MARAMA_13aug2021_v0

Inside MARAMA region

2016-to-2023 and 2016-to-2026 projection packets for all nonpoint sources were provided by MARAMA for the following states after updated data for AEO2021: 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

Projection factors were developed by industrial sector from 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; and either AEO2020 or AEO2021 to go from 2020 to 2023 and 2026. AEO2020 was used for Process Flow categories – paper, aluminum, glass, cement/lime, iron/steel – due to reported issues with AEO2021 that affected these categories. All other source categories used AEO2021. 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 nonpoint 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 1.25. Sources within the MARAMA region were not projected with these factors, but with the MARAMA-provided growth factors.

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. The EIA's AEO for year 2018 was used as a starting point for projecting volumes of finished fuel that would be transported in future years, i.e., 2023 and 2026. Then these volumes were used to calculate inventories associated with evaporative emissions in 2016, 2023, and 2026 using the upstream modules. Those emission inventories were mapped to the appropriate SCCs and projection packets were generated from 2016 to 2023 and 2016 to 2026 using the upstream modules. 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 are 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. 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 trustworthy 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.

2032 inventory

The 2032 nonpt inventory was created by projecting 2026 to 2032 to simplify the procedure and to keep these factors consistent throughout the platform.

All Volpe packets and the Cellulosic inventories stopped at 2028 because that was the last year available.

The MARAMA and PFC projection packets were developed from the MARAMA tool including updated AEO values and VMT to get the factors from 2026 to 2032.

A new 2026 to 2030 projection packet was created based on human population. The human population dataset used for projections does not contain population estimates beyond 2030, to 2030 population was used to represent 2032. A new 2026 to 2032 projection packet was created for industrial sources based on AEO 2021.

4.2.3.9 Solvents (solvents)

Packets:

Projection_2016_2023_solvents_v2platform_from_oilgas_30jun2021_v0
Projection_2016_2023_solvents_v2platform_MARAMA_20aug2021_v1
Projection_2016_2023_solvents_v2platform_NC_20aug2021_v1
Projection_2016_2023_solvents_v2platform_NJ_30jun2021_v0
Projection_2016_2023_solvents_v2platform_population_30jun2021_v0
Projection_2016_2026_solvents_v2platform_from_oilgas_19jul2021_v0
Projection_2016_2026_solvents_v2platform_MARAMA_noNCNJ_19jul2021_v0
Projection_2016_2026_solvents_v2platform_NC_19jul2021_v0
Projection_2016_2026_solvents_v2platform_NJ_19jul2021_v0
Projection_2016_2026_solvents_v2platform_population_noMARAMA_19jul2021_v0
Projection_2026_2030_solvents_v2platform_population_noMARAMA_05aug2021_v0
Projection_2026_2032_solvents_v2platform_from_oilgas_05aug2021_v0
Projection_2026_2032_solvents_v2platform_MARAMA_20aug2021_v1

The projection methodology for solvents is the same as it was in 2016v1 platform when solvents were part of nonpt. 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 following updates were made to supplement the SCCs in the projection packets:

- changed 2461800001 to 2461800000;
- all 2460- SCCs and 2402000000 use human population (copied from an existing 2460- SCC);
- 2477777777 uses gas/oil average ("BOTH") production growth factors from np_oilgas;
- all other SCCs were already covered; two SCCs do not use projection factors and are held flat (2420000000 / dry cleaning held flat outside MARAMA region; 2461850000 / ag pesticide application held flat everywhere except North Carolina as NC provided their own factors).

The 2026 projection packets were interpolated from 2023 and 2028 for NC/NJ.

For 2032, the projections start from 2026. Separate NC/NJ packets were not available; so we just had the oil/gas, MARAMA-tool-based, and non-MARAMA pop-based. The population dataset used for the non-MARAMA populated-based packet only goes out to 2030, but the other packets are 2032.

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
Projection_2026_2032_rwc_version2_platform_fromMARAMA_05aug2021_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 and 2032 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.

Table 4-16 contains the factors to adjust the emissions from 2016 to 2026 and 2032. California, Oregon, and Washington RWC were held constant at NEI2014v2 levels for 2016, 2026, and 2032 due to the unique control programs those states have in place.

Table 4-16. Projection factors for RWC

SCC	SCC description	Pollutant*	2016-to-2023	2016-to-2026	2016-to-2032
2104008100	Fireplace: general		7.19%	10.29%	16.49%
2104008210	Woodstove: fireplace inserts; non-EPA certified		-13.92%	-17.97%	-17.97%
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic	PM10-PRI	4.09%	5.08%	5.08%
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic	PM25-PRI	4.09%	5.08%	5.08%
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic		8.34%	10.28%	10.28%
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic	PM10-PRI	6.06%	7.68%	7.68%
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic	PM25-PRI	6.06%	7.68%	7.68%
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic		12.08%	15.27%	15.27%
2104008310	Woodstove: freestanding, non-EPA certified	CO	-12.09%	-15.72%	-15.72%
2104008310	Woodstove: freestanding, non-EPA certified	PM10-PRI	-12.67%	-16.52%	-16.52%
2104008310	Woodstove: freestanding, non-EPA certified	PM25-PRI	-12.67%	-16.52%	-16.52%
2104008310	Woodstove: freestanding, non-EPA certified	VOC	-11.40%	-14.84%	-14.84%
2104008310	Woodstove: freestanding, non-EPA certified		-12.09%	-15.72%	-15.72%
2104008320	Woodstove: freestanding, EPA certified, non-catalytic	PM10-PRI	4.09%	5.08%	5.08%
2104008320	Woodstove: freestanding, EPA certified, non-catalytic	PM25-PRI	4.09%	5.08%	5.08%
2104008320	Woodstove: freestanding, EPA certified, non-catalytic		8.34%	10.28%	10.28%
2104008330	Woodstove: freestanding, EPA certified, catalytic	PM10-PRI	6.07%	7.69%	7.69%

SCC	SCC description	Pollutant*	2016-to-2023	2016-to-2026	2016-to-2032
2104008330	Woodstove: freestanding, EPA certified, catalytic	PM25-PRI	6.07%	7.69%	7.69%
2104008330	Woodstove: freestanding, EPA certified, catalytic		12.08%	15.27%	15.27%
2104008400	Woodstove: pellet-fired, general (freestanding or FP insert)	PM10-PRI	30.09%	38.02%	38.02%
2104008400	Woodstove: pellet-fired, general (freestanding or FP insert)	PM25-PRI	30.09%	38.02%	38.02%
2104008400	Woodstove: pellet-fired, general (freestanding or FP insert)		26.96%	33.85%	33.85%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	CO	-64.93%	-84.78%	-84.78%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	PM10-PRI	-62.99%	-82.89%	-82.89%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	PM25-PRI	-62.99%	-82.89%	-82.89%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	VOC	-65.02%	-84.89%	-84.89%
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified		-64.93%	-84.78%	-84.78%
2104008530	Furnace: Indoor, pellet-fired, general	PM10-PRI	30.09%	38.02%	38.02%
2104008530	Furnace: Indoor, pellet-fired, general	PM25-PRI	30.09%	38.02%	38.02%
2104008530	Furnace: Indoor, pellet-fired, general		26.96%	33.85%	33.85%
2104008610	Hydronic heater: outdoor	PM10-PRI	0.06%	-0.40%	-0.40%
2104008610	Hydronic heater: outdoor	PM25-PRI	0.06%	-0.40%	-0.40%
2104008610	Hydronic heater: outdoor		-0.73%	-1.30%	-1.30%
2104008620	Hydronic heater: indoor	PM10-PRI	0.06%	-0.40%	-0.40%
2104008620	Hydronic heater: indoor	PM25-PRI	0.06%	-0.40%	-0.40%
2104008620	Hydronic heater: indoor		-0.73%	-1.30%	-1.30%
2104008630	Hydronic heater: pellet-fired	PM10-PRI	0.06%	-0.40%	-0.40%
2104008630	Hydronic heater: pellet-fired	PM25-PRI	0.06%	-0.40%	-0.40%
2104008630	Hydronic heater: pellet-fired		-0.73%	-1.30%	-1.30%
2104008700	Outdoor wood burning device, NEC (fire-pits, chimineas, etc)		7.19%	9.25%	9.25%
2104009000	Fire log total		7.19%	9.25%	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)

The final step in the projection of emissions to a future year is the application of any control technologies or programs. For future-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 future 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, 2026 and 2032 projections:

Equation 4-2

$$\text{Control Efficiency}_{202x}(\%) = 100 \times \left(1 - \frac{\left[(Pf_{202x} - 1) \times Fn + (1 - Ri)^{12} + \left(1 - (1 - Ri)^{12}\right) \times Fn\right]}{Pf_{202x}}\right)$$

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 (future 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 4-17 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 2028 emissions for the 2016v1 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 4-17. 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

NSPS Rule	Sector(s)	Retirement Rate years (%/year)	Pollutant Impacted	Applied where?	New Source Emission Factor (Fn)
				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_v2_platform_23jun2021_v0
Control_2016_2023_OilGas_NSPS_pt_oilgas_v2_platform_23jun2021_v0
Control_2016_2026_OilGas_NSPS_np_oilgas_v2_platform_23jun2021_v0
Control_2016_2026_OilGas_NSPS_pt_oilgas_v2_platform_23jun2021_v0
Control_2016_2032_OilGas_NSPS_np_oilgas_v2_platform_23jun2021_v0
Control_2016_2032_OilGas_NSPS_pt_oilgas_v2_platform_23jun2021_v0

New packets to reflect the oil and gas NSPS were developed for the 2016v2 platform. For oil and gas NSPS controls, except for gas well completions (a 95 percent control), the assumption of no equipment retirements through year 2028 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 4-17, 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 4-18 (np_oilgas) and Table 4-20 (pt_oilgas) list the SCCs where Oil and Gas NSPS controls were applied; note controls are applied to production and exploration-related SCCs. Table 4-19 (np_oilgas) and Table 4-21 (pt_oilgas) shows the reduction in VOC emissions in states other than the WRAP states after the application of the Oil and Gas NSPS CONTROL packet for future years.

Table 4-18. Non-point (np_oilgas) SCCs in 2016v1 and 2016v2 modeling platform where Oil and Gas NSPS controls applied

SCC	SRC_TYPE	OILGAS NSPS CATEGORY	TOOL OR STATE SCC	SRC CAT TYPE	SCCDESC
2310010200	OIL	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Crude Petroleum; Oil Well Tanks - Flashing & Standing/Working/Breathing
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
2310011500	OIL	5. Fugitives	STATE	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
2310021010	NGAS	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Storage Tanks: Condensate
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	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Pneumatic Pumps
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	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: All Processes
2310021601	NGAS	2. Well Completions	STATE	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Venting - Initial Completions

SCC	SRC_TYPE	OILGAS NSPS CATEGORY	TOOL OR STATE SCC	SRC CAT TYPE	SCCDESC
2310030300	NGAS	1. Storage Tanks	STATE	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
2310421010	NGAS	1. Storage Tanks	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production - Unconventional; Storage Tanks: Condensate
2310421700	NGAS	2. Well Completions	STATE	EXPLORATION	Gas Well Completion: All Processes Unconventional

Table 4-19. Emissions reductions for np_oilgas sector due to application of Oil and Gas NSPS

year	poll	2016v2	2016 pre-CoST emissions	emissions change from 2016	% change
2023	VOC	2405032	2467173	-519753	-21.1%
2026	VOC	2405032	2467173	-677742	-27.5%
2032	VOC	2405032	2467173	-715125	-29.0%

Table 4-20. Point source SCCs in pt_oilgas sector where Oil and Gas NSPS controls were applied.

SCC	FUEL PRODUCED	OILGAS NSPS CATEGORY	SCCDESC
31000101	Oil	2. Well Completions	Industrial Processes; Oil and Gas Production; Crude Oil Production; Well Completion
31000130	Oil	4. Compressor Seals	Industrial Processes; Oil and Gas Production; Crude Oil Production; Fugitives: Compressor Seals
31000133	Oil	1. Storage Tanks	Industrial Processes; Oil and Gas Production; Crude Oil Production; Storage Tank
31000151	Oil	3. Pnuematic controllers: high or low bleed	Industrial Processes; Oil and Gas Production; Crude Oil Production; Pneumatic Controllers, Low Bleed
31000152	Oil	3. Pnuematic controllers: high or low bleed	Industrial Processes; Oil and Gas Production; Crude Oil Production; Pneumatic Controllers High Bleed >6 scfh
31000207	Gas	5. Fugitives	Industrial Processes; Oil and Gas Production; Natural Gas Production; Valves: Fugitive Emissions
31000220	Gas	5. Fugitives	Industrial Processes; Oil and Gas Production; Natural Gas Production; All Equipt Leak Fugitives (Valves, Flanges, Connections, Seals, Drains

SCC	FUEL PRODUCED	OILGAS NSPS CATEGORY	SCCDESC
31000222	Gas	2. Well Completions	Industrial Processes; Oil and Gas Production; Natural Gas Production; Well Completions
31000225	Gas	4. Compressor Seals	Industrial Processes; Oil and Gas Production; Natural Gas Production; Compressor Seals
31000233	Gas	3. Pnuematic controllers: high or low bleed	Industrial Processes; Oil and Gas Production; Natural Gas Production; Pneumatic Controllers, Low Bleed
31000309	Gas	4. Compressor Seals	Industrial Processes; Oil and Gas Production; Natural Gas Processing; Compressor Seals
31000324	Gas	3. Pnuematic controllers: high or low bleed	Industrial Processes; Oil and Gas Production; Natural Gas Processing; Pneumatic Controllers Low Bleed
31000325	Gas	3. Pnuematic controllers: high or low bleed	Industrial Processes; Oil and Gas Production; Natural Gas Processing; Pneumatic Controllers, High Bleed >6 scfh
31088811	Both	5. Fugitives	Industrial Processes; Oil and Gas Production; Fugitive Emissions; Fugitive Emissions

Table 4-21. VOC reductions (tons/year) for the pt_oilgas sector after application of the Oil and Gas NSPS CONTROL packet for both future years 2023, 2026 and 2032.

Year	Pollutant	2016v2	Emissions Reductions	% change
2023	VOC	226,805	-2,228	-1.0%
2026	VOC	226,805	-2,828	-1.2%
2032	VOC	226,805	-2,975	-1.3%

4.2.4.2 RICE NSPS (nonpt, ptnonipm, np_oilgas, pt_oilgas)

Packets:

CONTROL_2016_2023_RICE_NSPS_nonpt_ptnonipm_beta_platform_extended_04oct2019_v1
CONTROL_2016_2023_RICE_NSPS_ptnonipm_v1_platform_MARAMA_10sep2019_v0
Control_2016_2023_RICE_NSPS_pt_oilgas_v2_platform_23jun2021_v0
Control_2016_2026_RICE_NSPS_nonpt_v2_platform_16jul2021_v0
Control_2016_2026_RICE_NSPS_pt_oilgas_v2_platform_23jun2021_v0
Control_2016_2026_RICE_NSPS_np_oilgas_v2_platform_23jun2021_v0
Control_2016_2023_RICE_NSPS_np_oilgas_v2_platform_23jun2021_v0
Control_2023_2026interp_RICE_NSPS_ptnonipm_v2_platform_MARAMA_22jul2021_v0
Control_2023_2026interp_RICE_NSPS_ptnonipm_v2_platform_noMARAMA_22jul2021_v0
Control_2026_2032_RICE_NSPS_nonpt_ptnonipm_v2_platform_13aug2021_v0
Control_2016_2032_RICE_NSPS_pt_oilgas_v2_platform_23jun2021_v0
Control_2016_2032_RICE_NSPS_np_oilgas_v2_platform_23jun2021_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, the 2023 packets were reused from the 2016v1 platform. The 2026 packets were interpolated between 2023 and 2028. The 2026 to 2032 packets were developed using consistent methods to the other 2016v2 packets. For the pt_oilgas and np_oilgas sectors, year-specific RICE NSPS factors were generated for all 3 specific years 2023, 2026 and 2032. New growth factors based on AEO2021 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. The actual control efficiency calculation methodology did not change from 2016v1 to 2016v2. 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 4-17. Table 4-22, Table 4-23, and Table 4-27 list the SCCs where RICE NSPS controls were applied for the 2016v2 platform. Table 4-24, Table 4-25, Table 4-26 and Table 4-28. Emissions reductions (tons/year) in pt_oilgas sector after the application of the RICE NSPS CONTROL packet for future years 2023, 2026, and 2032.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 future years. Note that for nonpoint oil and gas, VOC reductions were only appropriate in the state of Pennsylvania.

Table 4-22. 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 4-23. Non-point Oil and Gas SCCs in 2016v2 modeling platform where RICE NSPS controls applied

SCC	Lean, Rich, or Combined category	SRC_TYPE	TOOL OR STATE SCC	SRC CAT TYPE	SCCDESC
2310000220	Combined	BOTH	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Drill Rigs
2310000660	Combined	BOTH	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Hydraulic Fracturing Engines
2310020600	Combined	NGAS	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Natural Gas; Compressor Engines
2310021202	Lean	NGAS	TOOL	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	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Lateral Compressors 4 Cycle Lean Burn
2310021302	Rich	NGAS	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Natural

SCC	Lean, Rich, or Combined category	SRC_TYPE	TOOL OR STATE SCC	SRC CAT TYPE	SCCDESC
					Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP
2310021351	Rich	NGAS	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Lateral Compressors 4 Cycle Rich Burn
2310023202	Lean	CBM	TOOL	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	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Lateral Compressors 4 Cycle Lean Burn
2310023302	Rich	CBM	TOOL	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	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Lateral Compressors 4 Cycle Rich Burn
2310400220	Combined	BOTH	STATE	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; All Processes - Unconventional; Drill Rigs

Table 4-24. Nonpoint Emissions reductions after the application of the RICE NSPS

year	Poll	2016v2 (tons)	Emissions reductions (tons)	% change
2023	CO	1,897,760	-17,374	-0.9%
2023	NOX	692,492	-24,339	-3.5%
2026	CO	1,897,760	-21,639	-1.1%
2026	NOX	692,492	-31,207	-4.5%
2032	CO	1,897,760	-28,129	-1.5%
2032	NOX	692,492	-42,028	-6.1%

Table 4-25. Ptnonipm Emissions reductions after the application of the RICE NSPS

year	poll	2016v2 (tons)	Emissions reductions (tons)	% change
2023	CO	1,411,093	-1,994	-0.1%
2023	NOX	945,768	-2,513	-0.3%
2023	VOC	597,842	-2	0.0%
2026	CO	1,411,093	-2,258	-0.2%
2026	NOX	945,768	-2,894	-0.3%
2026	VOC	597,842	-2	0.0%
2032	CO	1,411,093	-2,691	-0.2%
2032	NOX	945,768	-3,535	-0.4%
2032	VOC	597,842	-3	0.0%

Table 4-26. Oil and Gas Emissions reductions for np_oilgas sector due to application of RICE NSPS

year	Poll	2016v2	2016pre-CoST emissions	Emissions reduction	% change
2023	CO	770832	748563	-90213	-12.1%
2023	NOX	575272	605920	-85510	-14.1%
2023	VOC	2405032	2467173	-497	0.0%
2026	CO	770832	748563	-119278	-15.9%
2026	NOX	575272	605920	-113547	-18.7%
2026	VOC	2405032	2467173	-686	0.0%
2032	CO	770832	748563	-150866	-20.2%
2032	NOX	575272	605920	-147020	-24.3%
2032	VOC	2405032	2467173	-827	0.0%

Table 4-27. 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 4-28. Emissions reductions (tons/year) in pt_oilgas sector after the application of the RICE NSPS CONTROL packet for future years 2023, 2026, and 2032.

Year	Pollutant	2016v2	Emissions Reductions	% change
2023	CO	205,547	-17,027	-8.3%
2023	NOX	409,699	-46,451	-11.3%
2023	VOC	226,805	-311	-0.1%
2026	CO	205,547	-22,259	-10.8%
2026	NOX	409,699	-62,219	-15.2%
2026	VOC	226,805	-430	-0.2%
2032	CO	205,547	-26,970	-13.1%
2032	NOX	409,699	-76,086	-18.6%
2032	VOC	226,805	-527	-0.2%

4.2.4.3 Fuel Sulfur Rules (nonpt, ptnonipm)

Packets:

Control_2016_202X_MANEVU_Sulfur_fromMARAMA_v1_platform_23sep2019_v0

The control packet for fuel sulfur rules is reused from the 2016v1 platform and is the same for all future years. Fuel sulfur rules controls are reflected for the following states: Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, 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.

Summaries of the sulfur rules by state, with emissions reductions relative to the entire sector emissions and relative to the future year emissions for the affected SCCs are provided in Table 4-29 and Table 4-30. These tables reflect the impacts of the MARAMA packet only, as these reductions are not estimated in non-MARAMA states. Most of these reductions occur in the nonpt sector; a small amount of reductions occurs in the ptnonipm sector, and a negligible amount of reductions occur in the pt_oilgas sector.

Table 4-29. Summary of fuel sulfur rule impacts on nonpoint SO2 emissions for 2023

year	poll	2016v2 (tons)	emissions reductions (tons)	% change (nonpt)
2023	SO2	135,604	-30,267	-22.3%

Table 4-29 (ctd.) Change in nonpoint emissions of affected SCCs due to fuel sulfur rule impacts by state

Pollutant	State	2023 pre-control Emissions (tons)	2023 post-control Emissions (tons)	Change in emissions (tons)	Percent change
NOX	Connecticut	3,778	3,505	-273	-7.2%
NOX	Delaware	441	413	-28	-6.3%
NOX	Maine	2,817	2,506	-311	-11.0%
NOX	Massachusetts	7,917	7,477	-440	-5.6%
NOX	New Hampshire	5,554	5,305	-249	-4.5%
NOX	New Jersey	2,111	1,868	-243	-11.5%
NOX	Pennsylvania	5,953	5,852	-101	-1.7%
NOX	Rhode Island	826	767	-59	-7.1%
NOX	Vermont	825	748	-77	-9.3%
NOX	**TOTAL**	**30,221**	**28,441**	**-1,780**	**-5.9%**
SO2	Connecticut	7,660	268	-7,392	-96.5%
SO2	Delaware	432	2	-430	-99.5%
SO2	Maine	5,711	83	-5,629	-98.6%
SO2	Massachusetts	6,776	242	-6,534	-96.4%
SO2	New Hampshire	4,043	20	-4,022	-99.5%
SO2	New Jersey	663	20	-643	-97.0%

Pollutant	State	2023 pre-control Emissions (tons)	2023 post-control Emissions (tons)	Change in emissions (tons)	Percent change
SO2	Pennsylvania	7,244	2,206	-5,038	-69.5%
SO2	Rhode Island	210	21	-189	-89.8%
SO2	Vermont	432	41	-391	-90.6%
SO2	**TOTAL**	**33,170**	**2,903**	**-30,267**	**-91.2%**

Table 4-30. Summary of fuel sulfur rule impacts on ptnonipm SO2 emissions for 2023 and 2028

year	Poll	2016v2 (tons)	emissions reductions (tons)	% change (ptnonipm)
2023	SO2	648,529	-1,177	-0.2%

Table 4-30 (ctd). Change in ptnonipm emissions of affected SCCs due to fuel sulfur rule impacts by state

Pollutant	State	2023 pre-control emissions (tons)	2023 post-control emissions (tons)	Change in emissions (tons)	Percent change
NOX	Connecticut	72	70	-2	-3.5%
NOX	Delaware	167	162	-5	-3.0%
NOX	Maine	316	307	-9	-2.8%
NOX	Massachusetts	293	286	-7	-2.5%
NOX	New Hampshire	21	19	-1	-6.4%
NOX	New Jersey	208	200	-8	-3.7%
NOX	Pennsylvania	298	289	-9	-3.1%
NOX	Rhode Island	118	115	-3	-2.7%
NOX	Vermont	0	0	0	-15.0%
NOX	**TOTAL**	**1,493**	**1,448**	**-45**	**-3.0%**
SO2	Connecticut	6	0	-5	-94.0%
SO2	Delaware	111	48	-62	-56.3%
SO2	Maine	470	106	-363	-77.4%
SO2	Massachusetts	349	144	-205	-58.7%
SO2	New Hampshire	350	75	-275	-78.6%
SO2	New Jersey	15	0	-15	-97.0%
SO2	Pennsylvania	180	79	-101	-56.0%
SO2	Rhode Island	236	111	-125	-53.0%
SO2	Vermont	34	9	-26	-75.0%
SO2	**TOTAL**	**1,750**	**573**	**-1,177**	**-67.3%**

4.2.4.4 Natural Gas Turbines NO_x NSPS (ptnonipm, pt_oilgas)

Packets:

CONTROL_2016_2023_Natural_Gas_Turbines_NSPS_ptnonipm_beta_platform_extended_04oct2019_v1
CONTROL_2016_2023_NG_Turbines_NSPS_ptnonipm_v1_platform_MARAMA_10sep2019_v0
Control_2016_2023_NG_Turbines_NSPS_pt_oilgas_v2_platform_28jun2021_nf_v1
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_v2_platform_28jun2021_nf_v1
Control_2026_2032_NG_Turbines_NSPS_ptnonipm_v2_platform_13aug2021_v0
Control_2016_2032_NG_Turbines_NSPS_pt_oilgas_v2_platform_20aug2021_v1

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; and the packet from 2026 to 2032 was developed using methods consistent with how the 2023 and 2028 packets were developed. For pt_oilgas, the packets for 2016v2 are based on updated growth information for that sector from state-historical production data and the AEO2021 production forecast database. The new growth factors were to calculate the new control efficiencies for all future years (2023, 2026, and 2032). The control efficiency calculation methodology did not change from 2016v1 to 2016v2 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. The map showing the states and partial-states in the NO_x SIP Call Program can be found at: https://www.epa.gov/airmarkets/programs and more recently https://www.epa.gov/airmarkets/final-update-nox-sip-call-regulations. 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

NOx Emission Limits for New Stationary Combustion Turbines				
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, but not for 2032 since MARAMA factors were not available beyond 2028.

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 future 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
20300202	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine
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	2016v2 (tons)	emissions reduction (tons)	% change
2023	NOX	945,768	-2,098	-0.2%
2026	NOX	945,768	-2,440	-0.3%
2032	NOX	945,768	-3,165	-0.3%

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 future years.

Year	Pollutant	2016v2	Emissions Reduction	% change
2023	NOX	409,699	-8,160	-2.0%
2026	NOX	409,699	-11,357	-2.8%
2032	NOX	409,699	-14,039	-3.4%

4.2.4.5 Process Heaters NO_x NSPS (ptnonipm, pt_oilgas)

Packets:

Control_2016_2023_Process_Heaters_NSPS_ptnonipm_beta_platform_ext_25sep2019_v0
Control_2023_2026interp_Process_Heaters_NSPS_ptnonipm_v2_platform_22jul2021_v0
Control_2016_2023_Process_Heaters_NSPS_pt_oilgas_v2_platform_23jun2021_v0
Control_2016_2026_Process_Heaters_NSPS_pt_oilgas_v2_platform_23jun2021_v0
Control_2026_2032_Process_Heaters_NSPS_ptnonipm_v2_platform_13aug2021_v0
Control_2016_2032_Process_Heaters_NSPS_pt_oilgas_v2_platform_23jun2021_v0

For ptnonipm, the control packet for 2023 was reused for 2016v1 platform; the packet for 2023 to 2026 was developed based on an interpolation between the 2023 and 2028 factors for 2016v1 platform; and the 2026 to 2032 packet was developed using methods consistent with how the 2023 and 2028 packets were developed. For pt_oilgas, the packets were newly developed for 2016v2 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 (Fe)	**Fraction at this rate**		
PPMV	**Natural Draft**	**Forced Draft**	**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 future years.

Table 4-37. Ptnonipm SCCs in 2016v1 modeling platform where Process Heaters NSPS controls applied.

scc	**Sccdesc**
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

scc	Sccdesc
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	2016v2 (tons)	emissions reduction (tons)	% change
2023	NOX	945,768	-9,311	-1.0%
2026	NOX	945,768	-11,286	-1.2%
2032	NOX	945,768	-16,371	-1.7%

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 futures years.

Year	Pollutant	2016v2	Emissions Reduction	% change
2023	NOX	409,699	-1,592	-0.4%
2026	NOX	409,699	-2,095	-0.5%
2032	NOX	409,699	-2,599	-0.6%

4.2.4.6 CISWI (ptnonipm)

Packets:

Control_2016_202X_CISWI_ptnonipm_beta_platform_ext_25sep2019_v0

The 2016v1 packet for CISWI was reused in the 2016v2 platform and is the same for all future years.

On March 21, 2011, the EPA promulgated the revised NSPS and emission guidelines for Commercial and Industrial Solid Waste Incineration (CISWI) units. This was a response to the voluntary remand that was granted in 2001 and the vacatur and remand of the CISWI definition rule in 2007. In addition, the standards redevelopment included the 5-year technology review of the new source performance standards and emission guidelines required under Section 129 of the Clean Air Act. The history of the CISWI implementation is documented here: https://www.epa.gov/stationary-sources-air-pollution/commercial-and-industrial-solid-waste-incineration-units-ciswi-new. Baseline and CISWI rule impacts associated with the CISWI rule are documented here: https://www.regulations.gov/document?D=EPA-HQ-OAR-2003-0119-2559. The EPA mapped the units from the CISWI baseline and controlled dataset to the 2014 NEI inventory and computed percent reductions such that our future year emissions matched the CISWI controlled dataset values. Table 4-41 summarizes the total impact of CISWI controls for 2023 and 2028. Note that this rule applies to specific units in 11 states: Alaska, Arkansas, Illinois, Iowa, Louisiana, Maine, Oklahoma, Oregon, Pennsylvania, Tennessee, and Texas for CO, SO2, and NOX.

Table 4-41. Summary of CISWI rule impacts on ptnonipm emissions for 2023

year	pollutant	2016v2 (tons)	emissions reductions (tons)	% change
2023	CO	1,411,093	-2,791	-0.2%
2023	NOX	945,768	-2,002	-0.2%
2023	SO2	648,529	-1,815	-0.3%

4.2.4.7 Petroleum Refineries NSPS Subpart JA (ptnonipm)

Packets:

Control_2016_202X_NSPS_Subpart_Ja_ptnonipm_beta_platform_ext_25sep2019_v0

The 2016v1 packet for Subpart JA was reused in the 2016v2 platform and is the same for all future years. On June 24, 2008, EPA issued final amendments to the Standards of Performance for Petroleum Refineries. This action also promulgated separate standards of performance for new, modified, or reconstructed process units after May 14, 2007 at petroleum refineries. The final standards for new process units included emissions limitations and work practice standards for fluid catalytic cracking units, fluid coking units, delayed coking units, fuel gas combustion devices, and sulfur recovery plants. In 2012, EPA finalized the rule after some amendments and technical corrections. See https://www.epa.gov/stationary-sources-air-pollution/petroleum-refineries-new-source-performance-standards-nsps-40-cfr for more details on NSPS – 40 CFR 60 Subpart Ja. These NSPS controls were applied to petroleum refineries in the ptnonipm sector for years 2023 and 2028. Units impacted by this rule were identified in the 2016v1 inventory. For delayed coking units, an 84% control efficiency was applied and for storage tanks, a 49% control efficiency was applied. The analysis of applicable units was completed prior to the 2014v2 NEI and the 2016v1 platform. Therefore, to ensure that a control was not applied to a unit that was already in compliance with this rule, we compared emissions from the 2016v1 inventory and the 2011en inventory (the time period of the original analysis). Any unit that demonstrated a 55+% reduction in VOC emissions from 2011en to 2016v1 would be considered compliant with the rule and therefore not subject to this control. Table 4-42 below reflects the impacts of these NSPS controls on the ptnonipm sector. This control is applied to all pollutants; Table 4-42 summarizes reductions for the future years for NOX, SO2, and VOC.

Table 4-42. Summary of NSPS Subpart JA rule impacts on ptnonipm emissions for 2023 and 2028

year	pollutant	2016v1 (tons)	emissions reductions (tons)	% change
2023	NOX	945,768	-1	0.0%
2023	SO2	648,529	-3	0.0%
2023	VOC	597,842	-5,269	-0.9%

4.2.4.8 Ozone Transport Commission Rules (nonpt, solvents)

Packets:

Control_2016_202X_nonpt_OTC_v1_platform_MARAMA_04oct2019_v1
Control_2016_202X_nonpt_PFC_v1_platform_MARAMA_04oct2019_v1

The 2016v1 packets are reused and are the same for all years.

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.

4.2.4.9 State-Specific Controls (ptnonipm)

Packets:

Control_2016_202X_ptnonipm_NC_BoilerMACT_beta_platform_ext_25sep2019_v0
Control_2016_202X_AZ_Regional_Haze_ptnonipm_beta_platform_ext_25sep2019_v0
CONTROL_2016_202X_Consent_Decrees_ptnonipm_v1_platform_MARAMA_10sep2019_v0
CONTROL_2016_202X_DC_supplemental_ptnonipm_v1_platform_04oct2019_v1
CONTROL_2016_202X_Consent_Decrees_other_state_comments_beta_platform_extended_20aug2021_v2

ICI Boilers – North Carolina

The Industrial/Commercial/Institutional Boilers and Process Heaters MACT Rule, hereafter simply referred to as the “Boiler MACT,” was promulgated on January 31, 2013, based on reconsideration.

Background information on the Boiler MACT can be found at: https://www.epa.gov/stationary-sources-air-pollution/industrial-commercial-and-institutional-boilers-and-process-heaters. The Boiler MACT promulgates national emission standards for the control of HAPs (NESHAP) for new and existing industrial, commercial, and institutional (ICI) boilers and process heaters at major sources of HAPs. The expected cobenefit for CAPs at these facilities is significant and greatest for SO2 with lesser impacts for direct PM, CO and VOC. This control addresses only the expected cobenefits to existing ICI boilers in the State of North Carolina. All other states previously considered for this rule are assumed to be in compliance with the rule and therefore the emissions need no further estimated controls applied. The control factors applied here were provided by North Carolina.

Arizona Regional Haze Controls

U.S. EPA Region 9 provided regional haze FIP controls for a few industrial facilities. Information on these controls are available in the docket https://www.regulations.gov/document?D=EPA-R09-OAR-2013-0588-0072. These non-EGU controls have implementation dates between September 2016 and December 2018.

Consent Decrees

MARAMA provided a list of controls relating to consent decrees to be applied to specific units within the MARAMA region. This list includes sources in North Carolina that were subject to controls in the beta version of this emission modeling platform. Outside of the MARAMA region, controls related to consent decrees were applied to several sources, including the LaFarge facility in Michigan (8127411), for which NOX emissions must be reduced by 18.633% to meet the decree; and the Cabot facilities in Louisiana and Texas, which had been subject to consent decree controls in the 2011 platforms, and 2016 emissions values suggest controls have not yet taken effect. Other facilities subject to a consent decree were determined to already be in compliance based on 2016 emissions values.

For 2016v2, an update to the NOx control efficiencies for the Minntac facility (6927911) was implemented based on reduction information from Minnesota Pollution Control Agency. In 2016v1, the reduction was nearly 95% for the full facility and has been updated to reduce five units with the majority of the NOX emissions by 33-37% each.

State Comments

A comment from the State of Illinois that was included in the 2011 platform was carried over for the 2016v1 platform. The data accounts for three coal boilers being replaced by two gas boilers not in the inventory and results in a large SO2 reduction.

The State of Ohio reported that the P. H. Glatfelter Company facility (8131111) has switched fuels after 2016, and so controls related to the fuel switch were applied. This is a new control for version 1 platform.

Comments relating to Regional Haze in the 2011 platform were analyzed for potential use in the 2016v1 platform. For those comments that are still applicable, control efficiencies were recalculated so that 2016v1 post-control emissions (without any projections) would equal post-control emissions for the 2011 platform (without any projections). This is to ensure that controls which may already be applied are accounted for. Some facilities' emissions were already less than the 2011 post-control value in 2016v1 and therefore did not need further controls here. For facility 3982311 (Eastman Chemical in Tennessee), one unit has a control efficiency of 90 in 2016v1 and the others have no control; a replacement control of 91.675 was applied for this facility so that the unit with control efficiency=90 is not double controlled.

Wisconsin provided alternate emissions to use as input to 2023v1/2028v1 CoST. Wisconsin provided new emissions totals for three facilities and requested that these new totals be used as the basis for 2023v1 and 2028v1 projections, instead of 2016v1. The provided emissions were facility-level only, therefore 2016v1 emissions were scaled at these facilities to match the new provided totals.

The District of Columbia provided a control packet to be applied to three ptnonipm facilities in all 2016v1 platform projections.

4.3 Projections Computed Outside of CoST

Projections for some sectors are not calculated using CoST. These are discussed in this section.

4.3.1 Nonroad Mobile Equipment Sources (nonroad)

Outside California and Texas, the MOVES3 model was run separately for each future year, including 2023, 2026, and 2032, resulting in a separate inventory for each year. The fuels used are specific to each future year, but the meteorological data represented the year 2016. The 2023, 2026, and 2032 nonroad emission factors account for regulations such the Emissions Standards for New Nonroad Spark-Ignition Engines, Equipment, and Vessels (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-nonroad-spark-ignition), Locomotives 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), and Clean Air Nonroad Diesel Final Rule – Tier 4 (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-air-pollution-nonroad-diesel). The resulting future 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 2023 and 2028. CARB also provided a nonroad dataset for 2035. The 2023 California and Texas datasets were used as provided. For 2026, we interpolated the 2023 and 2028 datasets in both California and Texas. The California 2032 nonroad dataset is an interpolation of 2028 and 2035. Since we do not have any TCEQ datasets beyond 2028, the 2032 Texas nonroad dataset was projected from the TCEQ-based 2026 dataset using projection factors based on the MOVES runs from 2026 and 2032 by county, SCC, and pollutant. The 2032 Texas nonroad projection was built from 2026 rather than 2028 because we did not have a 2028 MOVES run consistent with the 2026 and 2032 MOVES runs for 2016v2 platform. VOC and $PM_{2.5}$ by speciation profile, and VOC HAPs, were added to all future year California and Texas nonroad inventories using the same procedure as for the 2016 inventory, but based on the future year MOVES runs instead of the 2016 MOVES run.

The nonroad inventories 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;
- Growth and control from Locomotives and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder: March, 2008; and
- Clean Air Nonroad Diesel Final Rule – Tier 4: May, 2004.

4.3.2 Onroad Mobile Sources (onroad)

The MOVES3 model was run separately for each future year, including 2023, 2026, and 2032, resulting in separate emission factors for each year. The 2023, 2026, and 2032 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 (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-new-motor-vehicles-and-2), local fuel programs, and Stage II refueling control programs.

The fuels used are specific to each future year, the age distributions were projected to the future year, and the meteorological data represented the year 2016. The resulting emission factors were combined with future year activity data using SMOKE-MOVES run in a similar way as the base year. The development of the future year activity data is described later in this section. CARB provided separate emissions datasets for each future year. The CARB-provided emissions were adjusted to match the temporal and spatial patterns of the SMOKE-MOVES based emissions. Additional information about the development of future year onroad emission and on how SMOKE was run to develop the emissions can be found in the 2016v1 platform onroad sector specification sheet.

Future year VMT was 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 backcasting, EPA calculated county-road type factors based on FHWA VM-2 County 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.

- 2019 VMT were projected to 2023 using a combination of AEO2020 and AEO2021 reference case tables. AEO2021 starts with the year 2020, so AEO2020 was used to project from 2019 to 2020, and AEO2021 was used to project from 2020 to 2023.
- VMT data submitted by state and local agencies for the year 2023 for the 2016 version 1 platform were 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 and 2032 using AEO2021. Thus the 2026 and 2032 projected VMT used 2023 as the baseline and incorporated submitted 2023 VMT.

Annual VMT data from the AEO2020 and AEO2021 reference cases by fuel and vehicle type were used to project VMT from 2019 to future 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 factions, total VMT for each MOVES fuel and vehicle grouping was calculated for the years 2019, 2023, 2026, and 2032 based on the AEO-to-MOVES mappings above. From these totals, 2019-2023, 2023-2026, and 2023-2032 VMT trends were calculated for each fuel and vehicle grouping. Those trends became the national VMT projection factors. The AEO2021 tables include data starting from the year 2020. Since we were using AEO data to project from 2019, 2019-to-2020 projection factors were calculated from AEO2020, and then multiplied by 2020-to-future projection factors from AEO2021. MOVES fuel and vehicle types were mapped to AEO fuel and vehicle classes. The resulting 2019-to-future year national VMT projection factors used for the 2016v2 platform are provided in Table 4-43 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, 2026, and 2030[35] (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 4-43. Factors used to Project VMT to future years

SCC6	description	2019 to 2023 factor	2023 to 2026 factor	2023 to 2032 factor
220111	LD gas	1.13	1.04	1.09
220121	LD gas	1.13	1.04	1.09
220131	LD gas	1.13	1.04	1.09
220132	LD gas	1.13	1.04	1.09

[35] The final year of the population dataset used is 2030

SCC6	description	2019 to 2023 factor	2023 to 2026 factor	2023 to 2032 factor
220142	Buses gas	1.03	1.01	1.12
220143	Buses gas	1.03	1.01	1.12
220151	MHD gas	1.03	1.01	1.12
220152	MHD gas	1.03	1.01	1.12
220153	MHD gas	1.03	1.01	1.12
220154	MHD gas	1.03	1.01	1.12
220161	HHD gas	0.67	0.80	0.68
220221	LD diesel	1.37	1.17	1.40
220231	LD diesel	1.37	1.17	1.40
220232	LD diesel	1.37	1.17	1.40
220241	Buses diesel	1.091	1.05	1.11
220242	Buses diesel	1.09	1.05	1.11
220243	Buses diesel	1.09	1.05	1.11
220251	MHD diesel	1.09	1.05	1.11
220252	MHD diesel	1.09	1.05	1.11
220253	MHD diesel	1.09	1.05	1.11
220254	MHD diesel	1.09	1.05	1.11
220261	HHD diesel	1.08	1.04	1.06
220262	HHD diesel	1.08	1.04	1.06
220342	Buses CNG	1.12	0.99	0.98
220521	LD E-85	1.05	0.96	0.85
220531	LD E-85	1.05	0.96	0.85
220532	LD E-85	1.05	0.96	0.85
220921	LD Electric	2.28	1.40	2.64
220931	LD Electric	2.28	1.40	2.64
220932	LD Electric	2.28	1.40	2.64

In areas where the EPA default future year VMT projection were used, future 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 future year projected VMT to estimate future year VPOP. Future year VPOP data submitted by state and local agencies were incorporated into the VPOP projections for 2023. Future 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 version 1 platform in CT, GA, MA, and the Louisville metro areas; as those areas only submitted VMT for 2023 and not VPOP, but keeping the 2016 version 1 VPOP in those areas ensures consistency between the VMT and VPOP. Additionally, North Carolina bus VMT and VPOP, which was an EPA default projection in version 1 platform, was carried forward from version 1 platform so that all VMT and VPOP in North Carolina would be the same as in version 1. Both VMT and VPOP were redistributed between the LD car and truck vehicle types (21/31/32) based on splits from the EPA computed default projection.

Hoteling hours were projected to the future 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 future year projected VMT for combination long-haul trucks on restricted roads to calculate future 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 future years. This procedure gives county-total hoteling for the future years. Each future 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, 20.46% for 2026, and 31.72% APU for 2032. New Jersey provided 2023 hoteling data for 2016v1 and those data were used for the 2016v2, using the new APU fraction for MOVES3 2023 (12.91%). As in the 2016 backcast, for counties that had 2017 hoteling, but do not have vehicle type 62 VMT on restricted road type - that is, 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.

Future year starts were calculated using 2017NEI-based VMT ratios, similar to how 2016 starts were calculated:

Future year STARTS = Future year VMT * (2017 STARTS / 2017 VMT by county+SCC6)

Future 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:

Future year ONI = Future 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. EMFAC2017 was run by CARB for the years 2016, 2023, 2028, and 2035. California onroad emissions for 2026 were interpolated from CARB 2023 and 2028, and emissions for 2032 were interpolated from CARB 2028 and 2035.

4.3.3 Locomotives (rail)

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 future year of 2030 were based on future 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 4-44) and emission factors based on historic emissions trends that reflect the rate of market penetration of new locomotive engines. The locomotive projections only go to 2030 to be consistent with the out year for the commercial marine vessel projections.

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 future year Class I line-haul fuel use totals for 2020, 2023, 2026, and 2030. As shown in Table 4-44 the future 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 4-44. 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 future 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 was aggregated to create county, state, and national emissions estimates (see Table 4-45) which were then converted into FF10 format for use in the 2016v2 emissions platform.

Table 4-45. Class I Line-haul Historic and Future 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 4-46. See the 2016v1 rail specification sheet for additional information on rail projections.

Table 4-46. 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 2016v1 platform, applied to the 2016v2 platform base year inventories.

For 2016v1 platform, ECCC provided data from which Canadian future 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 (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. As noted below, inventories projected to 2028 were often used to represent the year 2032 due to lack of information for later years. 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, and emissions from 2028 were used to represent the year 2032. As with the base year, the future year dust emissions are pre-adjusted, so future 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 future years. Since the othptdust projections in 2016v1 were nearly flat, we decided to not project othptdust for the v2 platform (i.e., the 2016fj othptdust emissions were reused for all future 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, and emissions from 2028 were used to represent the year 2032. 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, and 2028 emissions were used to represent 2032.

In 2016v1 platform, future 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 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 2016v2 platform. Similar to the procedure for projecting Canadian stationary point sources, factors for projecting from 2016 to 2023 and 2028 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, and 2028 emissions were used to represent 2032.

4.3.4.3 Nonpoint sources in Canada and Mexico (othar)

Canadian stationary sources

In 2016v1 platform, future 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 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.

For 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 future years. Therefore, the 2016v1 area source EPG inventory was included in the 2016v2 platform future year cases. Emissions for 2026 were interpolated from 2023 and 2028, and 2028 emissions were used to represent 2032.

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.

Instead of using 2028 mobile source emissions to represent 2032, additional projections out to 2032 were applied to the Canada nonroad and rail inventories. For nonroad, national projection factors by fuel, nonroad equipment sector, and pollutant were calculated from the US MOVES runs for 2026 and 2032 (excluding California and Texas for which we did not use MOVES data) and applied to the interpolated 2026 Canada nonroad inventory. The 2026 Canada nonroad inventory was used as the baseline for the 2032 projection rather than 2028, because we did not have a MOVES run for 2028 which is consistent with the 2026 and 2032 MOVES3 runs performed for 2016v2 platform. For rail, factors for projecting 2026 Canadian rail to 2032 were the same as the factors used to project US rail emissions from 2026 to 2030 (used to represent 2032), based on the 2018 AEO.

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 proejctions were calculated for the area and nonroad inventories. Emissions for 2026 were interpolated between 2023 and 2028, and 2028 emissions were used to represent 2032, 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.

Instead of using 2028 mobile source emissions to represent 2032, additional projections out to 2032 were applied to the Canada onroad inventory. National projection factors distinguishing gas from diesel, light duty from heavy duty, refueling from non-refueling, and pollutant were calculated from the US MOVES runs for 2026 and 2032 (excluding California for which we did not use MOVES data) and applied to the interpolated 2026 Canada onroad inventory. The 2026 Canada onroad inventory was used as the baseline for the 2032 projection rather than 2028, because we did not have a MOVES3 run for 2028 which is consistent with the 2026 and 2032 MOVES runs performed for 2016v2 platform.

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, 2026 emissions were interpolated between 2023-2028, and 2032 emissions were interpolated between 2028-2035. MOVES-Mexico emissions for 2035 were not available from the 2016v1 platform, so a new MOVES-Mexico run was performed for 2035 to support the 2032 interpolation. The 2035 MOVES-Mexico run included diesel refueling whereas 2016/2023/2028 did not; we excluded diesel refueling from the 2032 interpolation.

5 Emission Summaries

Tables 5-1 through Table 5-4 summarize emissions by sector for the 2016fj, 2023fj, and 2032fj 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 5-5 and Table 5-6 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/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 includes CMV emissions at U.S. ports. "Offshore" represents CMV emissions that are outside of U.S. state waters. Canadian CMV emissions are included in the other sector. The total of all US sectors is listed as "Con U.S. Total."

Table 5-7 and Table 5-8 summarize ozone season NOx and VOC emissions, respectively, for the 2016fj, 2023fj, 2026fj and 2032fj cases.

State totals and other summaries are available in the reports area on the web and FTP sites for the 2016v2 platform (https://www.epa.gov/air-emissions-modeling/2016v2-platform, https://gaftp.epa.gov/Air/emismod/2016/v2)

Table 5-1. National by-sector CAP emissions for the 2016fj case, 12US1 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,314,612	880,002		
airports	486,237	0	126,713	10,011	8,733	15,245	54,191
cmv_c1c2	23,548	83	162,502	4,457	4,320	634	6,436
cmv_c3	13,956	39	110,462	2,201	2,025	4,528	8,600
fertilizer		1,183,387					
livestock		2,493,166					224,459
nonpt	1,878,357	109,393	685,856	517,279	438,112	134,178	823,345
nonroad	10,593,504	1,845	1,110,243	109,008	103,047	1,513	1,134,711
np_oilgas	767,276	20	573,037	12,540	12,454	42,741	2,394,024
onroad	18,309,739	107,903	3,394,103	225,510	106,447	25,960	1,310,505
pt_oilgas	195,388	283	369,113	13,003	12,453	44,162	225,116
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
ptegu	658,496	24,039	1,319,734	164,090	133,543	1,565,675	33,748
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	1,403,822	62,974	933,618	391,071	249,030	644,852	593,789
rail	104,551	326	559,381	16,344	15,819	457	26,082
rwc	2,230,849	16,943	35,204	309,908	309,019	8,249	334,217
solvents	0	0	0	0	0	0	2,841,997
beis	3,973,014		983,247				26,791,907
CONUS + beis	**54,639,227**	**4,291,614**	**10,600,953**	**9,592,386**	**3,537,687**	**2,603,295**	**39,934,957**
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	10,741	37	93,456	1,682	1,563	2,984	5,184
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	33,224	128	293,102	7,188	6,658	28,060	16,209
Offshore cmv outside Federal waters	23,338	440	257,615	24,827	22,847	181,941	11,083
Offshore pt_oilgas	50,052	15	48,691	668	667	502	48,210
Non-U.S. Total	**8,472,751**	**659,759**	**2,804,698**	**1,529,403**	**621,172**	**1,598,894**	**2,617,684**

Table 5-2. National by-sector CAP emissions for the 2023fj case, 12US1 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,401,391	899,185		
airports	517,268	0	145,795	10,055	8,806	17,694	57,943
cmv_c1c2	23,570	59	116,344	3,191	3,093	242	4,527
cmv_c3	17,076	48	107,609	2,699	2,483	5,537	10,602
fertilizer		1,183,387					
livestock		2,626,271					235,783
nonpt	1,891,033	110,651	694,255	521,019	443,557	102,467	778,316
nonroad	10,581,631	2,032	737,604	70,997	66,494	974	863,250
np_oilgas	768,609	30	586,759	14,862	14,735	61,972	2,389,864
onroad	13,148,561	100,915	1,655,937	191,255	61,836	10,813	831,291
pt_oilgas	225,150	309	403,961	17,092	16,178	64,753	223,469
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
ptegu	427,367	36,995	594,744	114,785	98,246	634,036	37,919
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	1,432,679	61,885	908,799	382,640	244,237	534,410	588,194
rail	105,988	330	469,157	12,778	12,376	460	20,436
rwc	2,207,381	16,741	36,863	302,976	302,069	7,705	330,560
solvents	0	0	0	0	0	0	2,972,209
beis	3,973,014		983,247				26,791,907
Con. U.S. Total + beis	**49,319,818**	**4,430,866**	**7,678,812**	**9,548,093**	**3,435,978**	**1,556,166**	**39,267,692**
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	11,597	40	67,837	1,819	1,690	3,158	5,525
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	39,846	150	257,244	8,460	7,815	34,951	19,345
Offshore cmv outside Federal waters	28,551	277	314,614	15,643	14,396	41,490	13,542
Offshore pt_oilgas	50,052	15	48,691	668	667	502	48,210
Non-U.S. Total	**8,214,481**	**751,715**	**2,484,865**	**1,593,349**	**617,415**	**1,289,500**	**2,527,359**

Table 5-3. National by-sector CAP emissions for the 2026fj case, 12US1 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,428,543	905,256		
Airports	533,307	0	152,022	10,214	8,952	18,502	59,667
cmv_c1c2	23,816	52	101,403	2,788	2,702	243	3,889
cmv_c3	18,598	52	107,790	2,941	2,705	6,021	11,587
Fertilizer		1,183,387					
Livestock		2,676,214					240,237
Nonpt	1,901,236	110,845	697,001	525,570	448,103	101,118	750,750
Nonroad	10,751,235	2,075	654,121	62,250	58,069	993	823,108
np_oilgas	759,656	30	572,137	14,987	14,859	64,530	2,420,875
Onroad	11,585,277	101,412	1,349,183	191,676	56,943	10,458	712,159
pt_oilgas	228,771	326	410,387	17,670	16,735	66,401	227,428
Ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
Ptegu	375,426	37,372	524,517	105,766	91,749	527,497	38,012
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	1,447,666	62,195	922,900	385,646	246,557	538,782	589,066
Rail	108,411	338	441,525	11,683	11,317	468	18,709
Rwc	2,197,235	16,670	37,264	300,528	299,616	7,523	329,169
Solvents	0	0	0	0	0	0	3,061,634
Beis	3,973,014		983,247				26,791,907
Con. U.S. Total + beis	**47,904,137**	**4,482,184**	**7,191,237**	**9,562,611**	**3,426,245**	**1,457,639**	**39,209,617**
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	11,987	41	70,985	1,880	1,747	3,280	5,709
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	43,378	163	247,179	9,172	8,466	38,601	21,050
Offshore cmv outside Federal waters	31,251	304	344,269	17,136	15,769	45,504	14,821
Offshore pt_oilgas	50,052	15	48,691	668	667	502	48,210
Non-U.S. Total	**8,086,882**	**802,052**	**2,387,283**	**1,648,376**	**628,367**	**1,302,035**	**2,593,311**

Table 5-4. National by-sector CAP emissions for the 2032fj case, 12US1 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,458,049	912,011		
airports	567,555	0	165,344	10,576	9,283	20,226	63,334
cmv_c1c2	24,263	43	85,429	2,338	2,266	246	3,319
cmv_c3	20,561	58	107,190	3,253	2,992	6,651	12,856
fertilizer		1,183,387					
livestock		2,732,952					245,305
nonpt	1,903,520	110,928	687,427	528,664	452,252	97,673	730,932
nonroad	11,248,705	2,165	562,189	52,589	48,733	1,043	801,700
np_oilgas	729,184	30	538,818	14,811	14,683	64,244	2,408,435
onroad	8,679,801	102,102	1,019,701	191,468	50,703	9,770	585,930
pt_oilgas	225,894	321	401,808	17,779	16,835	67,026	226,979
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
ptegu	451,570	36,761	604,700	116,719	100,420	713,590	40,632
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	1,448,923	62,326	919,014	386,807	247,646	538,255	588,692
rail	108,120	337	417,808	10,029	9,716	466	15,775
rwc	2,210,901	16,833	37,501	302,689	301,777	7,559	331,058
solvents	0	0	0	0	0	0	3,152,515
beis	3,973,014		983,247				26,791,907
Con. U.S. Total + beis	**45,592,497**	**4,539,456**	**6,767,916**	**9,598,120**	**3,431,999**	**1,641,852**	**39,130,792**
Can./Mex./Offshore							
Sector	**CO**	**NH3**	**NOX**	**PM10**	**PM2_5**	**SO2**	**VOC**
Canada ag		666,106					104,732
Canada oil and gas 2D	511	7	1,208	136	136	3,713	471,499
Canada othafdust				854,957	132,557		
Canada othar	2,207,683	3,708	224,883	214,775	156,436	16,153	755,356
Canada onroad_can	1,176,830	6,505	156,013	25,852	8,338	846	67,108
Canada othpt	1,170,310	23,893	457,199	77,957	46,065	868,995	163,782
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	12,790	43	71,970	1,970	1,829	3,531	6,061
Mexico othar	132,782	110,719	75,549	109,362	37,260	2,095	435,707
Mexico onroad_mex	1,595,504	4,195	383,146	20,987	14,132	9,392	173,325
Mexico othpt	136,413	1,528	209,778	67,100	46,303	307,141	51,870
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	47,889	179	234,630	10,084	9,300	43,171	23,268
Offshore cmv outside Federal waters	34,680	337	381,968	19,029	17,510	50,589	16,450
Offshore pt_oilgas	50,052	15	48,691	668	667	502	48,210
Non-U.S. Total	**7,710,009**	**837,703**	**2,277,997**	**1,684,916**	**634,144**	**1,315,644**	**2,634,342**

Table 5-5. National by-sector CAP emissions for the 2016fj case, 36US3 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,318,693	880,413		
Airports	486,976	0	126,863	10,036	8,756	15,268	54,284
cmv_c1c2	22,299	79	154,053	4,230	4,100	608	6,126
cmv_c3	13,634	38	107,651	2,137	1,966	4,394	8,426
Fertilizer		1,183,387					
Livestock		2,493,168					224,459
Nonpt	1,879,030	109,453	686,374	517,360	438,157	134,419	823,601
Nonroad	10,598,518	1,845	1,110,424	109,045	103,082	1,514	1,135,706
np_oilgas	767,276	20	573,037	12,540	12,454	42,741	2,394,024
onroad	18,316,814	107,918	3,394,861	225,566	106,476	25,961	1,311,039
pt_oilgas	195,388	283	369,113	13,003	12,453	44,162	225,116
ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
Ptegu	658,548	24,039	1,319,935	164,096	133,548	1,565,684	33,754
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	1,403,836	62,974	933,635	391,098	249,038	644,852	593,790
Rail	104,551	326	559,381	16,344	15,819	457	26,082
Rwc	2,255,921	16,972	35,693	314,353	313,464	8,325	334,819
Solvents	0	0	0	0	0	0	2,842,494
Beis	4,135,928		997,794				27,766,644
36US3 U.S. Total + beis	**54,839,208**	**4,291,714**	**10,606,555**	**9,600,852**	**3,542,409**	**2,603,488**	**40,911,786**
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	13,768	49	121,623	2,288	2,122	5,165	6,733
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	36,315	163	322,278	9,143	8,466	40,887	17,403
Offshore cmv outside Federal waters	88,395	1,175	1,006,880	92,499	85,125	683,740	40,266
Offshore pt_oilgas	50,052	15	48,691	668	667	502	48,210
Annual Total	**27,621,887**	**1,342,884**	**6,027,100**	**3,959,307**	**2,308,297**	**3,586,022**	**7,997,363**

Table 5-6. National by-sector CAP emissions for the 2023fj case, 36US3 grid (tons/yr)

Sector	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
afdust_adj				6,405,476	899,596		
Airports	518,068	0	145,956	10,083	8,833	17,720	58,047
cmv_c1c2	22,224	56	109,865	3,030	2,937	225	4,273
cmv_c3	16,709	46	104,555	2,623	2,413	5,380	10,397
fertilizer		1,183,387					
livestock		2,626,273					235,783
Nonpt	1,891,745	110,722	694,794	521,086	443,601	102,705	778,566
Nonroad	10,586,164	2,032	737,740	71,022	66,517	975	863,939
np_oilgas	768,609	30	586,759	14,862	14,735	61,972	2,389,864
Onroad	13,153,476	100,929	1,656,397	191,305	61,855	10,814	831,668
pt_oilgas	225,150	309	403,961	17,092	16,178	64,753	223,469
Ptagfire	262,645	51,276	10,240	38,688	26,951	3,694	17,181
Ptegu	427,367	36,995	594,744	114,785	98,246	634,036	37,919
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	1,432,698	61,885	908,821	382,667	244,245	534,410	588,195
Rail	106,036	331	469,545	12,789	12,387	460	20,454
Rwc	2,229,940	16,769	37,302	306,911	306,005	7,774	331,137
Solvents	0	0	0	0	0	0	2,972,706
Beis	4,135,928		997,794				27,766,644
36US3 U.S. Total + beis	**49,514,603**	**4,430,978**	**7,685,971**	**9,556,085**	**3,440,230**	**1,556,326**	**40,244,484**
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	14,789	52	88,545	2,463	2,285	5,507	7,134
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	43,338	191	280,425	10,740	9,920	50,540	20,650
Offshore cmv outside Federal waters	108,334	741	1,234,211	58,174	53,534	155,668	49,468
Offshore pt_oilgas	50,052	15	48,691	668	667	502	48,210
Non-U.S. Total	**8,214,481**	**751,715**	**2,484,865**	**1,593,349**	**617,415**	**1,289,500**	**2,527,359**

Table 5-7. National by-sector Ozone Season NOx emissions summaries 12US1 grid (tons/o.s.)

Sector	2016fj	2023fj	2026fj	2032fj
airports	56,300	64,779	67,546	73,465
cmv_c1c2_12	90,624	64,719	56,294	47,300
cmv_c3_12	264,816	277,635	287,826	300,207
nonpt	193,886	196,857	198,442	195,724
nonroad	566,188	377,891	334,265	284,630
np_oilgas	239,247	244,056	238,015	224,204
onroad	1,341,526	650,732	523,684	387,755
onroad_ca_adj	99,730	48,303	44,880	41,490
pt_oilgas	175,250	189,944	192,640	189,043
ptagfire	3,193	3,193	3,193	3,193
ptegu	605,014	264,200	239,930	265,088
ptnonipm	391,374	381,066	386,919	385,113
rail	236,771	198,559	186,854	176,801
rwc	4,280	4,528	4,596	4,601
Total U.S. Anthro	**4,268,199**	**2,966,463**	**2,765,084**	**2,578,614**
beis	587,057	587,057	587,057	587,057
ptfire-rx	20,531	20,531	20,531	20,531
ptfire-wild	55,500	55,500	55,500	55,500
Grand Total	**4,931,288**	**3,629,551**	**3,428,173**	**3,241,702**

Table 5-8. National by-sector Ozone Season VOC emissions summaries 12US1 grid (tons/o.s.)

Sector	2016fj	2023fj	2026fj	2032fj
airports	24,078	25,745	26,511	28,140
cmv_c1c2_12	3,538	2,476	2,121	1,805
cmv_c3_12	14,553	17,965	19,716	21,943
livestock	156,077	164,112	167,229	170,725
nonpt	344,481	324,891	313,572	305,544
nonroad	573,637	421,807	398,145	383,526
np_oilgas	980,746	979,486	992,390	986,718
onroad	552,899	348,610	293,979	235,488
onroad_ca_adj	44,432	27,229	24,394	19,788
pt_oilgas	114,505	113,824	115,484	115,296
ptagfire	6,314	6,314	6,314	6,314
ptegu	16,215	17,999	18,313	18,934
ptnonipm	248,145	245,742	246,081	245,868
rail	11,039	8,648	7,917	6,674
rwc	36,554	37,983	38,361	38,408
solvents	1,194,840	1,249,563	1,287,153	1,325,357
Total U.S. Anthro	**4,322,053**	**3,992,395**	**3,957,681**	**3,910,526**
beis	20,896,708	20,896,708	20,896,708	20,896,708
ptfire-rx	277,019	277,019	277,019	277,019
ptfire-wild	1,005,261	1,005,261	1,005,261	1,005,261
Grand Total	**26,501,041**	**26,171,383**	**26,136,669**	**26,089,515**

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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.

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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 (-CEN).
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 profies 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

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