Technical Support Document (TSD)

Additional Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2023

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Note: this document has been updated from its original version to correct internal bookmarks in Sections 3.2.1.3 and 3.2.2

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Acronyms

AE5	CMAQ Aerosol Module, version 5, introduced in CMAQ v4.7
AE6	CMAQ Aerosol Module, version 6, introduced in CMAQ v5.0
AEO	Annual Energy Outlook
BAFM	Benzene, Acetaldehyde, Formaldehyde and Methanol
BEIS	Biogenic Emissions Inventory System
BELD	Biogenic Emissions Landuse Database
Bgal	Billion gallons
BPS	Bulk Plant Storage
BTP	Bulk Terminal (Plant) to Pump
C1/C2	Category 1 and 2 commercial marine vessels
C3	Category 3 (commercial marine vessels)
CAEP	Committee on Aviation Environmental Protection
CAIR	Clean Air Interstate Rule
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
CBM	Coal-bed methane
CEC	North American Commission for Environmental Cooperation
CEMS	Continuous Emissions Monitoring System
CEPAM	California Emissions Projection Analysis Model
CISWI	Commercial and Industrial Solid Waste Incinerators
Cl	Chlorine
CMAQ	Community Multiscale Air Quality
CMV	Commercial Marine Vessel
CO	Carbon monoxide
CSAPR	Cross-State Air Pollution Rule
CWFIS	Canadian Wildland Fire Information System
E0, E10, E85	0%, 10% and 85% Ethanol blend gasoline, respectively
EBAFM	Ethanol, Benzene, Acetaldehyde, Formaldehyde and Methanol
ECA	Emissions Control Area
EEZ	Exclusive Economic Zone
EF	Emission Factor
EGU	Electric Generating Units
EIS	Emissions Inventory System
EISA	Energy Independence and Security Act of 2007
EPA	Environmental Protection Agency
EMFAC	Emission Factor (California's onroad mobile model)
FAA	Federal Aviation Administration
FAPRI	Food and Agriculture Policy and Research Institute
FASOM	Forest and Agricultural Section Optimization Model
FCCS	Fuel Characteristic Classification System
FEPS	Fire Emission Production Simulator
FF10	Flat File 2010
FINN	Fire INventory from NCAR
FIPS	Federal Information Processing Standards

FHWA	Federal Highway Administration
HAP	Hazardous Air Pollutant
HCl	Hydrochloric acid
HDGHG	Heavy-Duty Vehicle Greenhouse Gas
Hg	Mercury
HMS	Hazard Mapping System
HPMS	Highway Performance Monitoring System
HWC	Hazardous Waste Combustion
HWI	Hazardous Waste Incineration
ICAO	International Civil Aviation Organization
ICI	Industrial/Commercial/Institutional (boilers and process heaters)
ICR	Information Collection Request
IDA	Inventory Data Analyzer
I/M	Inspection and Maintenance
IMO	International Marine Organization
IPAMS	Independent Petroleum Association of Mountain States
IPM	Integrated Planning Model
ITN	Itinerant
LADCO	Lake Michigan Air Directors Consortium
LDGHG	Light-Duty Vehicle Greenhouse Gas
LPG	Liquefied 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
Mgal	Million gallons
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
MSAT2	Mobile Source Air Toxics Rule
MTBE	Methyl tert-butyl ether
MWRPO	Mid-west Regional Planning Organization
NCD	National County Database
NEEDS	National Electric Energy Database System
NEI	National Emission Inventory
NESCAUM	Northeast States for Coordinated Air Use Management
NESHAP	National Emission Standards for Hazardous Air Pollutants
NH_3	Ammonia
NIF	NEI Input Format
NLCD	National Land Cover Database
NLEV	National Low Emission Vehicle program
nm	nautical mile
NMIM	National Mobile Inventory Model
NOAA	National Oceanic and Atmospheric Administration
NODA	Notice of Data Availability
NONROAD	EPA model for estimation of nonroad mobile emissions
NO_X	Nitrogen oxides
NSPS	New Source Performance Standards
NSR	New Source Review

OAQPS	EPA's Office of Air Quality Planning and Standards
OHH	Outdoor Hydronic Heater
OTAQ	EPA's Office of Transportation and Air Quality
ORIS	Office of Regulatory Information System
ORD	EPA's Office of Research and Development
ORL	One Record per Line
OTC	Ozone Transport Commission
PADD	Petroleum Administration for Defense Districts
PF	Projection Factor, can account for growth and/or controls
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
ppb, ppm	Parts per billion, parts per million
RBT	Refinery to Bulk Terminal
RFS2	Renewable Fuel Standard
RIA	Regulatory Impact Analysis
RICE	Reciprocating Internal Combustion Engine
RRF	Relative Response Factor
RWC	Residential Wood Combustion
RPO	Regional Planning Organization
RVP	Reid Vapor Pressure
SCC	Source Classification Code
SESQ	Sesquiterpenes
SMARTFIRE	Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOA	Secondary Organic Aerosol
SI	Spark-ignition
SIP	State Implementation Plan
SPDPRO	Hourly Speed Profiles for weekday versus weekend
SPPD	Sector Policies and Programs Division
TAF	Terminal Area Forecast
TCEQ	Texas Commission on Environmental Quality
TOG	Total Organic Gas
TSD	Technical support document
ULSD	Ultra Low Sulfur Diesel
USDA	U. S. Department of Agriculture
VOC	Volatile organic compound
VMT	Vehicle miles traveled
VPOP	Vehicle Population
WRAP	Western Regional Air Partnership
WRF	Weather Research and Forecasting Model

1 Introduction

In support of an analysis of the transport of ozone as it relates to the 2008 Ozone National Ambient Air Quality Standards (NAAQS), the U.S. Environmental Protection Agency (EPA) developed an air quality modeling platform based on the 2011 National Emissions Inventory (NEI), version 2 (2011NEIv2) with updates. The 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. The emissions modeling component of the modeling platform includes the emission inventories, the ancillary data files, and the approaches used to transform inventories for use in air quality modeling. The emissions modeling platform that corresponded to the air quality modeling platform for ozone transport related to the 2008 ozone NAAQS is known as the 2011v6.3 platform.

This document focuses on the *updates made* to the 2011v6.3 platform to support analyses of transport of zone related to the 2008 Ozone NAAQS. Much of the year 2011 data from the 2011v6.3 platform was unchanged for this updated platform and therefore the platform was not given a new number, although the future year of 2023 was used for this analysis as compared to 2017 for the original 2011v6.3 platform. For more information on the *original* 2011v6.3 platform and on any sectors or modeling techniques unchanged in this analysis, see the technical support document (TSD) *Preparation of Emission Inventories for the version 6.3, 2011 Emissions Modeling Platform* (EPA, 2016a), from August, 2016 available from EPA's Air Emissions Modeling web page for the version 6.3 platform: https://www.epa.gov/air-emissions-modeling/2011-version-63-platform. This web page also includes a link to the TSD *Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2023* (EPA, 2016b) that describes an earlier iteration of 2011 and 2023 emission cases that were released for public comment in January, 2017 (https://www.regulations.gov/document?D=EPA-HQ-OAR-2016-0751-0001). The updated platform described in *this document* includes additional updates as compared to the previously released and documented versions of the 2011v6.3 platform.

This 2011-based modeling platform includes all criteria air pollutants (CAPs) and precursors and the following hazardous air pollutants (HAPs): chlorine (Cl), hydrogen chloride (HCl), benzene, acetaldehyde, formaldehyde and methanol. The latter four HAPs are also abbreviated as BAFM. The air quality model used for this study is the Comprehensive Air Quality Model with Extensions (CAMx) model (http://www.camx.com/), version 6.40. However, emissions are first processed into a format compatible with for the Community Multiscale Air Quality (CMAQ) model (https://www.epa.gov/cmaq), version 5.0.2, and those emissions are converted into CAMx-ready formats.

Both CAMx and CMAQ support modeling ozone (O_3) and particulate matter (PM), and require as input hourly and gridded emissions of chemical species that correspond to CAPs and specific HAPs. The chemical mechanism used by CAMx for this platform is called Carbon Bond version 6 revision 4 (CB6r4). This version includes updated reactions, but the emissions species needed to drive this version are unchanged from the Carbon Bond version 6 revision 2 (CB6r2), which includes important reactions for simulating ozone formation, nitrogen oxides (NOx) cycling, and formation of secondary aerosol species (Hildebrant Ruiz and Yarwood, 2013). CB6 provides several revisions to the previous carbon bond version (CB05) through inclusion of four new explicit organic species: benzene, propane, acetylene and acetone, along with updates to reaction chemistry for those species and several other volatile organic chemicals (VOCs).

This update to the 2011v6.3 platform consists of two 'complete' emissions cases: the 2011 base case (i.e., 2011en_cb6v2_v6), and the 2023 base case (i.e., 2023en_cb6v2_v6), plus a source apportionment case with the same emissions as the 2023 base case but processed for ozone source apportionment. In the case abbreviations, 2011 and 2023 are the years represented by the emissions; the "e" stands for evaluation, meaning that year-specific data for fires and electric generating units (EGUs) are used; and the "n" represents that an iteration of emissions for the 2011-based modeling platform (i.e., the first case for the 2011 platform was 2011ea, the second was 2011eb, and so on). The purpose of the 2011 base case is to represent the year 2011 in a manner consistent with the methods used in corresponding future-year cases, including the 2023 future year base case, as well as any additional future year control and source apportionment cases. Table 1-1 provides more information on these emissions cases. This document describes any changes made since the original 2011v6.3 platform that included the cases 2011ek and 2017ek, thus any changes included in the cases 2011el and 2023el are described in addition to changes made for 2011en and 2023en.

For this application, the outputs from the 2011 base case are used in conjunction with the outputs from the 2023 base case in the relative response factor (RRF) calculations to identify future areas of nonattainment. For more information on the use of RRFs and air quality modeling, see "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM 2.5, and Regional Haze," available from http://www.epa.gov/ttn/scram/guidance/guide/final-03-pm-rh-guidance.pdf.

Table 1-1. List of cases in this update to the 2011 Version 6.3 Emissions Modeling Platform for 2023

Case Name	Abbreviation	Description
2011 base case	2011en_cb6v2_v6	2011 case relevant for air quality model evaluation purposes and for computing relative response factors with 2023 scenario(s). Uses 2011NEIv2 along with some other inventory data, with hourly 2011 continuous emissions monitoring system (CEMS) data for electric generating units (EGUs), hourly onroad mobile emissions, and 2011 day-specific wild and prescribed fire data. Wildfire inventories for Canada and Mexico were also included.
2023 base case	2023en_cb6v2_v6	2023 "base case" scenario, representing the best estimate for 2023 that incorporates estimates of the impact of current "on-the-books" regulations.
2023 source apportionment case	2023en_ussa_cb6v2_v6_11g	2023 emissions equivalent to those in the 2023el_cb6v2_v6 case, except that the emission sources are tagged according to their origin by state or sector.

All of the above cases use the same version of the 2011 meteorology and the cases are sometimes referred to with "_11g" after the emissions portion of the case name where "g" corresponds to the 7th configuration of the meteorological modeling platform, although the configuration is not exclusive to modeling of the year 2011. A special version of the 2023en_cb6v2_v6 case called 2023en_ussa_cb6v2_v6_11g was prepared for use with the CAMx OSAT/APCA feature that allowed the contribution of 2023 base case NOx and VOC emissions from all sources in each state to projected 2023 ozone concentrations at air quality monitoring sites to be quantified. The emissions for the case are equivalent to those in the 2023el_cb6v2_v6 case, except that the emission sources are tagged according to their origin by state or sector. The steps for setting up the 2023el_ussa_cb6v2_v6 source apportionment case include:

1) prepare files for the source groups to track (e.g., anthropogenic emissions from each state, non-geographic sector-specific tags for biogenic, fugitive dust, fire, and non-U.S. emissions);

2) run all sectors in Sparse Matrix Operator Kernel Emissions (SMOKE) using the specified source groups (note that emissions for both source apportionment and for a regular CAMx run can be developed simultaneously);
3) create CAMx point source files for source groups tracked only by sector;
4) convert SMOKE outputs to CAMx point source files using the tags assigned by SMOKE; and
5) merge all of the point source files together into a single CAMx mrgpt file for each day.

More information on processing for source apportionment is available with the scripts provided for the 2011v6.3 platform at ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/.

The emissions data in this platform are primarily based on the 2011NEIv2 for point sources, nonpoint sources, commercial marine vessels (CMV), nonroad mobile sources and fires. The onroad mobile source emissions are similar to those in the 2011NEIv2, but were generated using the released 2014a version of the Motor Vehicle Emissions Simulator (MOVES2014a) (http://www.epa.gov/otaq/models/moves/).

The primary emissions modeling tool used to create the air quality model-ready emissions was the SMOKE modeling system (https://www.cmascenter.org/smoke/). SMOKE version 3.7 was used to create emissions files for a 12-km national grid that includes all of the contiguous states "12US2," shown in Figure 3-1. Electronic copies of the data used as input to SMOKE for the cases for this update to the 2011v6.3 platform are available from the corresponding section of the EPA Air Emissions Modeling website, https://www.epa.gov/air-emissions-modeling/2011-version-63-platform.

The gridded meteorological model used for the emissions modeling was developed using the Weather Research and Forecasting Model (WRF, https://www.mmm.ucar.edu/weather-research-and-forecasting-model) version 3.4, 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 model was run for 2011 over a domain covering the continental U.S. at a 12km resolution with 35 vertical layers. The data output from WRF were collapsed to 25 layers prior to running the emissions and air quality models. 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 "11g" and are consistent with those used for the original 2011v6.3 platform cases.

This document contains five sections. Section 2 describes the changes made to the 2011 inventories input to SMOKE in this update to the 2011v6.3 platform. Section 3 describes the updates to emissions modeling and the ancillary files used to convert the emission inventories into air quality model-ready formats. Section 4, describes the development of the 2023 inventory (projected from 2011). Data summaries comparing the 2011 and 2023 base cases are provided in Section 5. Section 6 provides references.

2 2011 Emission Inventories and Approaches

This section describes the updates to the 2011 emissions data as compared to the 2011 case known as 2011ek_cb6v2_v6 in the 2011v6.3 platform (EPA, 2016a). Table 2-1 presents the sectors in this update to the 2011 platform that differ from the original 2011v6.3 plaform. The platform sector abbreviations are provided in italics. These sector abbreviations are used in the SMOKE modeling scripts, inventory file names, and throughout the remainder of this document. The remaining sectors for which 2011 emissions are unchanged from those in the 2011ek case are listed below in Table 2-2. Documentation for these sectors, plus additional information on the updated sectors, can be found in the original 2011v6.3 TSD (EPA, 2016a).

Table 2-1. Platform sectors updated since the original 2011v6.3 emissions modeling platform

Platform Sector: ***abbreviation***	**Description and resolution of the data input to SMOKE**
Biogenics: ***beis***	Emissions from natural vegetative sources. Minor corrections made to BELD4.1 landuse data used as input to BEIS3.61 (*updated in 2011en).*
Category 1 and 2 CMV: ***cmv_c1c2***	*New sector in 2011en:* Category 1 (C1) and category 2 (C2) commercial marine vessel (CMV) emissions sources using diesel fuel from the 2011NEIv2 nonpoint inventory. County and annual resolution; (*2011el included updated CMV emissions for California; emissions unchanged in 2011en but improved spatial surrogate is used)*
Category 3 CMV: ***cmv***	*New sector in 2011en:* Category 3 (C3) commercial marine vessel (CMV) emissions sources using residual fuel from the 2011NEIv2 nonpoint inventory including emissions in state and federal waters. In 2011en, this sector includes the ECA inventory for non-US, non-Canada waters that was formerly part of the othpt sector. County and annual resolution *(emissions totals unchanged from 2011el but new sector allows for plume rise treatment in 2011en).*
Non-point: ***nonpt***	Nonpoint sources not included in other sectors. 2011en includes a minor reduction to VOC emissions in New York state for Commercial/Industrial and Residential Natural Gas: Boilers and IC Engines (*updated in 2011en)*.
Nonroad: ***Nonroad***	Nonroad mobile source emissions based on 2011NEIv2. Inventory data consistent in 2011el and 2011en. In 2011en, temporal profiles for construction, lawn/garden (residential and commercial), and agriculture sources were updated (*temporal profiles updated in 2011en)*.
Onroad: ***onroad***	Onroad mobile source gasoline and diesel vehicles from parking lots and moving vehicles. Includes exhaust, extended idle, auxiliary power units, evaporative, permeation, refueling, and brake and tire wear. For all states, except California and Texas, based on monthly MOVES emissions tables produced by MOVES2014a. California emissions are based on Emission Factor (EMFAC) *and were updated in 2011el from the original 2011v6.3platform*. MOVES emissions for Texas provided by TCEQ for year 2012 were backcast to year 2011. MOVES-based emissions computed for each hour and model grid cell using monthly and annual activity data (e.g., VMT, vehicle population). *In 2011el, ethanol-85 usage in 2011 VMT was reduced to reflect actual percentage of E-85 used (changes in 2011el but none in 2011en).*

Platform Sector: ***abbreviation***	**Description and resolution of the data input to SMOKE**
EGU point sources: ***ptegu***	Point sources for electric generating units. In 2011en, minor changes were made to stack parameters, locations, and Continuous Emissions Monitoring System (CEMS) matching were made based on comments. Some sources moved into this sector from ptnonipm and out of the sector to ptnonipm also based on comments (*inventory and temporal profiles updated in 2011en).*
Non-US. fires: ***ptfire_mxca***	<u>*New Sector added in 2011el*</u>*:* Point source day-specific wildfires and prescribed fires for 2011 provided by Environment Canada with data for missing months and for Mexico filled in using fires from the Fire INventory from NCAR (FINN) fires (*emissions unchanged in 2011en).*
Non-EGU point sources: ***ptnonipm***	Point sources other than EGU and oil and gas production-related sources form 2011NEIv2. *In 2011en*, minor changes were made to stack parameters, locations, and CEMS matching were made based on comments. Some sources moved into this sector from ptegu and out of the sector to ptegu also based on comments (*updates specific to 2011en).*
Other point sources not from the 2011 NEI: ***othpt***	Offshore U.S. oil platforms from 2011NEIv2, plus point sources from Canada's **2013** inventory and Mexico's 2008 inventory *projected to 2011*, annual resolution. The *othpt* section was processed as a monthly sector because the 2013 Canadian airport point source inventory was at the monthly resolution. Also, for 2011en the ECA C3 for non-US/non-Canada CMV was moved into *cmv_c3 (2013 inventory for Canada is new in 2011en).*
Other area-fugitive dust not from 2011 NEI: ***othafdust***	Annual fugitive dust sources from Canada's **2013** inventory at province resolution. Export fraction and precipitation adjustments applied to this inventory to produce hourly, gridded emissions (*2013 for Canada is new in 2011en).*
Other non-NEI nonpoint and nonroad: ***othar***	Monthly year **2013** Canada (province resolution) and Mexico's 2008 nonpoint and nonroad mobile inventories *projected to 2011* (municipio resolution). Updated Canadian spatial surrogates along with population surrogate for Mexico (*new surrogates in 2011en and 2013 for Canada).*
Other non-NEI onroad sources: ***othon***	Monthly year **2013** Canada (province / annual resolution) onroad mobile inventories and *MOVES-Mexico emissions for 2011* (municipio / monthly resolution). Updated Canadian spatial surrogates and population surrogate for Mexico used (*new surrogates in 2011en and 2013 for Canada).*

Table 2-2. Platform sectors for which 2011 emissions are unchanged since the original 2011v6.3 emissions modeling platform

Platform Sector: *abbreviation*	NEI Data Category	Description and resolution of the data input to SMOKE
Area fugitive dust: ***afdust***	Nonpoint	PM_{10} and $PM_{2.5}$ fugitive dust sources from the 2011NEIv2 nonpoint inventory; including building construction, road construction, agricultural dust, and road dust. However, unpaved and paved road dust emissions differ from the NEI in that they do not have a precipitation adjustment. Instead, the emissions modeling adjustment applies a transport fraction and a meteorology-based (precipitation and snow/ice cover) zero-out. County and annual resolution. *Note: 2011 afdust emissions are unchanged from 2011ek and 2023 afdust emissions are unchanged from 2023el.*
Agricultural: ***ag***	Nonpoint	NH_3 emissions from 2011NEIv2 nonpoint livestock and fertilizer application, county and annual resolution. *Note: 2011 ag emissions are unchanged from 2011ek and 2023 ag emissions are unchanged from 2023el.*
Agricultural fires: ***agfire***	Nonpoint	2011NEIv2 agricultural fire sources, except for Missouri, which reverted to 2011NEIv1 based on comments. County and monthly resolution. *Note: agfire emissions are constant in the base and future years and unchanged from 2011ek.*
Nonpoint source oil and gas: ***np_oilgas***	Nonpoint	2011NEIv2 nonpoint sources from oil and gas-related processes with specific adjustments based on comments. County and annual resolution. Includes updates in Utah, and corrects sources in WRAP areas so that they are no-integrate and use WRAP speciation profiles. Additionally, new Texas inventory supplied by TCEQ, and modifications to Oklahoma (VOC-only changes) and West Virginia (SO2-only changes) inventories due to NODA comments. *Note: 2011 np_oilgas emissions are unchanged from 2011ek, but 2023 emissions have been updated in 2023en based on comments.*
Point source fires: ***ptfire***	Fires	Point source day-specific wildfires and prescribed fires for 2011 computed using SMARTFIRE2, except for Georgia and Florida-submitted emissions. Consistent with 2011NEIv2. *Note: ptfire emissions are constant in the base and future years and unchanged from 2011ek.*
Point source oil and gas: ***pt_oilgas***	Point	2011NEIv2 point sources that include oil and gas production emissions processes with specific updates to emissions and stack parameters based on comments and updates to control program order of precedence. Annual resolution. *Note: 2011pt_oilgas emissions are unchanged from 2011ek, but 2023 emissions have been updated in 2023en based on comments.*
Locomotives: ***rail***	Nonpoint	Rail locomotives emissions from the 2011NEIv2 with specific adjustments based on comments. *Note: 2011 rail emissions are unchanged from 2011ek and 2023 rail emissions are unchanged from 2023el.*
Residential Wood Combustion: ***rwc***	Nonpoint	2011NEIv2 NEI nonpoint sources with Residential Wood Combustion (RWC) processes. County and annual resolution. *Note: 2011 rwc emissions are unchanged from 2011ek and 2023 emissions are unchanged from 2023el.*

The emission inventories in SMOKE input format for the 2011 base case are available from the EPA's Air Emissions Modeling website for the version 6.3 platform, https://www.epa.gov/air-emissions-modeling/2011-version-63-platform. The README_2011en_2023en_package.txt file indicates the particular zipped files associated with each platform sector. The specific updated inventories for this platform can be found in the directories ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/2011en_update/ and ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/2023en_update/. Files in the ancillary_data directory and the 12km spatial surrogates have been updated to include all of the files for this update of the platform.

A number of reports (i.e., summaries) are available with the data files for the updated 2011v6.3 platform in ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/reports/2011en_and_2023en/. The types of reports include state summaries of inventory pollutants and model species by modeling platform sector, county annual totals by modeling platform sector, daily NOx and VOC emissions by sector and total, and state-SCC-sector summaries. A comparison of the complete list of inventory files, ancillary files, and parameter settings with those for the 2011v6.3 platform is also available in *2011v6.3_ek_el_en_case_inputs.xlsx*.

The remainder of Section 2 provides details about the data contained in each of the 2011 platform sectors that were modified from the original 2011v6.3 platform.

2.1 2011 point sources (ptegu, ptnonipm, pt_oilgas)

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). With a couple of minor exceptions, this section describes only NEI point sources within the contiguous U.S. The NEI is split into three point sectors: the EGU sector for non-peaking units (ptegu), point source oil and gas extraction-related emissions (pt_oilgas) – including off-shore oil platforms, and the remaining non-EGU sector (ptnonipm) sector. 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 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 2011NEIv2), 2011 hourly CEMS NO_X and SO_2 emissions were used rather than NEI emissions, and for all other pollutants, annual emissions were used as-is from the NEI, but were allocated to hourly values using heat input CEMS data. EGUs without CEMS are allocated to hourly data base on IPM region- and pollutant-specific temporal profiles as discussed in Section 3.3.3.

The inventory pollutants processed through SMOKE for all point source sectors were: CO, NO_X, VOC, SO_2, ammonia (NH_3), PM_{10}, and $PM_{2.5}$ and the following HAPs: HCl (pollutant code = 7647010), and Cl (code = 7782505). The inventory BAFM from these sectors was not used, instead VOC was speciated to these pollutants without any use (i.e., integration) of the VOC HAP pollutants from the inventory.

Minor updates were made to some sources in the ptnonipm sector to address comments on the January, 2017 Notice of Data Availability (NODA) as follows:

1. Added four Connecticut municipal waste combustor (MWC) units to ptnonipm from ptegu, and removed two Wheelabrator Bridgeport units to be moved to ptegu. For the new ptnonipm sources, blanked out the ORIS IDs and NEEDS_ID fields.
2. NC closures from pre2011_nc_ptnonipm_closures.xlsx were applied to ptnonipm. We confirmed that all of those facilities/units listed were in ptnonipm, and not ptegu/pt_oilgas.

Updates were made to some sources in the ptegu sector to address comments on the NODA and other updated data updates as follows:

1. Updated some FIPS codes and latitudes/longitudes based on the information in the CEMS reporting data.
2. Updated stack parameters as specified in Kansas NODA comments.
3. For Unit 21257713 in Texas (IPM_YN = 7097_B_BLR1; former ORIS facility 7097, ORIS boiler **1), blanked out ORIS IDs to make that unit a non-CEM source so that inventory emissions are used instead of CEMs, in particular for SO2.
4. Moved four Connecticut MWCs to ptnonipm, and added two Wheelabrator Bridgeport units from ptnonipm.

2.1.1 EGU sector (ptegu)

The ptegu sector contains emissions from EGUs in the 2011NEIv2 point inventory that could be matched to units found in the NEEDS v5.16 database that includes the units for which the Integrated Planning Model (IPM) predicts emissions. The ptegu sector indication is used in this modeling even though IPM was not used to derive the future year emissions. 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. Many of these matches are stored within the Emission Inventory System (EIS) that is used to create the NEI. In some cases, it was difficult to match the sources between the databases due to different facility names in the two data systems and due to differences in how the units are defined, thereby resulting in matches that are not always one-to-one. Some additional matches were made in the modeling platform to accommodate some of these situations as described later in this section.

Some units in the ptegu sector are matched to CEMS data via ORIS facility codes and boiler ID. For matched units, SMOKE replaces the 2011 emissions of NO_X and SO_2 with the CEMS emissions, thereby ignoring the annual values specified in the NEI. For other pollutants, the hourly CEMS heat input data are used to allocate the NEI annual emissions to hourly values. All stack parameters, stack locations, and SCC codes for these sources come from the NEI. 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 is 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. The EIS stores many matches from EIS units to the ORIS facility codes and boiler IDs used to reference the CEMS data. Some additional matches were made in the modeling platform as described later in this section.

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 CAMD 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 are not included in the CAMD hourly CEMS programs. Therefore, there will be more units in the NEEDS database than have CEMS data. The temporalization of EGU units matched to CEMS is based on the CEMS data in the base and future years are based on the base year CEMS data for those units, whereas regional profiles are used for the remaining units. More detail can be found in Section 3.3.3.

Matches between the NEI and NEEDS were identified by identifying units in IPM outputs that were not yet matched to NEI data, and by looking for units identified in the NEI with facility type codes identifying them as EGUs or facility names that indicated they were EGUs. In each case, priority was given to units with larger emissions (e.g., > 300TPY of NO_x or SO_2). The units in each data set that did not yet have matches within the same county were compared to one another on the basis of their plant names and locations. In some cases, IDs were similar but were mismatched only due to a missing leading zero in one of the databases. In other cases, a facility level match was specified, but a unit/boiler level match was not yet identified and, therefore, the units at the facility were compared to one another on the basis of design capacity and naming. For any new matches that were found, values that represented the NEEDS IDs were filled in to the IPM_YN in the modeling platform flat files. When possible, these matches were loaded into EIS. When new matches were identified, EGUs that otherwise would have remained in the ptnonipm sector were moved to the ptegu sector.

A similar process was used to identify additional matches between the 2011NEIv2 and CEMS data. To determine whether a NEI unit matched a CEMS unit, the CEMS units were compared to facilities in the NEI that were not yet identified as a CEMS unit on the basis of their county FIPS codes, locations, and total emissions of NO_x and SO_2. Additional CEMS matches that were found were applied to the FF10 file by specifying values for ORIS_FACILITY_CODE, ORIS_BOILER_ID. Because IPM uses a concatenation of the ORIS facility code and boiler ID, values were also filled in to the IPM_YN field for these units. Many new CEMS assignments were loaded into EIS for use in future inventories. Note that SMOKE can perform matches of CEMS data down to the stack or release point-level, which is finer than unit-level.

2.1.2 Point source oil and gas sector (pt_oilgas)

The pt_oilgas sector was separated from the ptnonipm sector by selecting sources with specific NAICS codes shown in Table 2-3. The emissions and other source characteristics in the pt_oilgas sector are submitted by states, while the EPA developed a dataset of nonpoint oil and gas emissions for each county in the U.S. with oil and gas activity that was available for states to use. Nonpoint oil and gas emissions can be found in the np_oilgas sector. More information on the development of the 2011 oil and gas emissions can be found in Section 3.20 of the 2011NEIv2 TSD.

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

NAICS	NAICS description
2111	Oil and Gas Extraction
2212	Natural Gas Distribution

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

2.1.3 Non-IPM sector (ptnonipm)

Except for some minor exceptions, the non-IPM (ptnonipm) sector contains the 2011NEIv2 point sources that are not in the 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 sector includes some ethanol plants that have been identified by EPA and require special treatment in the future cases as they are impacted by mobile source rules.

The ptnonipm sector contains a small amount of fugitive dust PM emissions from vehicular traffic on paved or unpaved roads at industrial facilities, coal handling at coal mines, and grain elevators. Sources with state/county FIPS code ending with "777" are in the 2011NEIv2 but are not included in any modeling sectors. These sources typically represent mobile (temporary) asphalt plants that are only reported for some states, and are generally in a fixed location for only a part of the year and are, therefore, difficult to allocate to specific places and days as is needed for modeling. Therefore, these sources are dropped from the point-based sectors in the modeling platform.

<u>EPA estimates for ethanol facilities</u>

As ethanol plants are important facilities for mobile source rules that have impact development work, the EPA developed a list of corn ethanol facilities for 2011. Ethanol facilities that were not in 2011NEIv1 were added into 2011NEIv2. Some adjustments were made to these based on comments. Locations and FIPS codes for these ethanol plants were verified using web searches and Google Earth. The EPA believes that some of these sources were not originally included in the NEI as point sources because they do not meet the 100 ton/year potential-to-emit threshold for NEI point sources. Emission rates for the ethanol plants were obtained from EPA's updated spreadsheet model for upstream impacts developed for the Renewable Fuel Standard (RFS2) rule (EPA, 2010a). Plant emission rates for criteria pollutants used to estimate impacts for years 2011 (and are assumed to be the same in the future) are given in Table 2-4.

Table 2-4. Corn Ethanol Plant Criteria Pollutant Emission Factors (grams per gallon produced)

Corn Ethanol Plant Type	VOC	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	NH_3
Dry Mill Natural Gas (NG)	2.29	0.58	0.99	0.94	0.23	0.01	0.00

Corn Ethanol Plant Type	VOC	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	NH_3
Dry Mill NG (wet distillers grains with solubles (DGS))	2.27	0.37	0.63	0.91	0.20	0.00	0.00
Dry Mill Biogas	2.29	0.62	1.05	0.94	0.23	0.01	0.00
Dry Mill Biogas (wet DGS)	2.27	0.39	0.67	0.91	0.20	0.00	0.00
Dry Mill Coal	2.31	2.65	4.17	3.81	1.71	4.52	0.00
Dry Mill Coal (wet DGS)	2.31	2.65	2.65	2.74	1.14	2.87	0.00
Dry Mill Biomass	2.42	2.55	3.65	1.28	0.36	0.14	0.00
Dry Mill Biomass (wet DGS)	2.35	1.62	2.32	1.12	0.28	0.09	0.00
Wet Mill NG	2.35	1.62	1.77	1.12	0.28	0.09	0.00
Wet Mill Coal	2.33	1.04	5.51	4.76	2.21	5.97	0.00

Air toxic emission rates were estimated by applying toxic to VOC ratios in Table 2-5, and were multiplied by facility production estimates for 2011 and 2018 based on analyses performed for the industry characterization described in Chapter 1 of the RFS2 final rule regulatory impact analysis. For air toxics, except ethanol, the toxic-to-VOC ratios were developed using emission inventory data from the 2005 NEI (EPA, 2009a).

Table 2-5. Toxic-to-VOC Ratios for Corn Ethanol Plants

	Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	Formaldehyde
Wet Mill NG	0.02580	0.00131	0.00060	2.82371E-08	0.00127
Wet Mill Coal	0.08242	0.00015	0.00048	2.82371E-08	0.00108
Dry Mill NG	0.01089	0.00131	0.00060	2.82371E-08	0.00127
Dry Mill Coal	0.02328	0.00102	0.00017	2.82371E-08	0.00119

2.2 2011 nonpoint sources (afdust, ag, agfire, np_oilgas, rwc, nonpt)

Several modeling platform sectors were created from the 2011NEIv2 nonpoint inventory. This section describes the *stationary* nonpoint sources. Locomotives, C1 and C2 CMV, and C3 CMV are also included the 2011NEIv2 nonpoint data category, but are mobile sources that are described in Sections 2.4.1 and 2.4.2 as the CMV and rail sectors, respectively. The 2011NEIv2 TSD available from https://www.epa.gov/air-emissions-inventories/2011-national-emissions-inventory-nei-documentation includes documentation for the nonpoint sector of the 2011NEIv2 Stationary nonpoint sources that were not subdivided into the afdust, ag, np_oilgas, or rwc sectors were assigned to the “nonpt” sector.

The nonpoint tribal-submitted emissions 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 scales used for this platform.

For the 2011en case, the only change in the nonpt sector was based on a comment from MARAMA regarding natural gas combustion SCCs in the state of New York. The *Commercial/Residential* (SCC=2103006000) and *Residential* (SCC=2104006010) *Natural Gas; Total Boilers and IC Engines* VOC emissions were both reduced by about 25% in New York state. This resulted in about a 575-ton reduction in VOC emissions.

The following subsections describe how the sources in the 2011NEIv2 nonpoint inventory were separated into 2011 modeling platform sectors, along with any data that were updated replaced with non-NEI data.

2.2.1 Area fugitive dust sector (afdust)

The area-source fugitive dust (afdust) sector contains PM_{10} and $PM_{2.5}$ emission estimates for nonpoint SCCs identified by EPA staff 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.

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 with a script that applies land use-based gridded transport fractions 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 (e.g., 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.

The sources in the afdust sector are for SCCs and pollutant codes (i.e., PM_{10} and $PM_{2.5}$) that are considered to be "fugitive" dust sources. These SCCs are provided in Table 2-6.

Table 2-6. SCCs in the afdust platform sector

SCC	SCC 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
2296005000	Mobile Sources;Unpaved Roads;Public Unpaved Roads;Total: Fugitives
2296010000	Mobile Sources;Unpaved Roads;Industrial Unpaved Roads;Total: Fugitives
2311000000	Industrial Processes;Construction: SIC 15 - 17;All Processes;Total
2311010000	Industrial Processes;Construction: SIC 15 - 17;Residential;Total
2311020000	Industrial Processes;Construction: SIC 15 - 17;Industrial/Commercial/Institutional;Total
2311030000	Industrial Processes;Construction: SIC 15 - 17;Road Construction;Total
2311040000	Industrial Processes;Construction: SIC 15 - 17;Special Trade Construction;Total
2325000000	Industrial Processes;Mining and Quarrying: SIC 14;All Processes;Total
2325020000	Industrial Processes;Mining and Quarrying: SIC 14;Crushed and Broken Stone;Total
2325030000	Industrial Processes;Mining and Quarrying: SIC 14;Sand and Gravel;Total

SCC	SCC Description
2801000000	Miscellaneous Area Sources;Agriculture Production - Crops;Agriculture - Crops;Total
2801000002	Miscellaneous Area Sources;Agriculture Production - Crops;Agriculture - Crops;Planting
2801000003	Miscellaneous Area Sources;Agriculture Production - Crops;Agriculture - Crops;Tilling
2801000005	Miscellaneous Area Sources;Agriculture Production - Crops;Agriculture - Crops;Harvesting
2801000008	Miscellaneous Area Sources;Agriculture Production - Crops;Agriculture - Crops;Transport
2805001000	Miscellaneous Area Sources;Agriculture Production - Livestock;Beef cattle - finishing operations on feedlots (drylots);Dust Kicked-up by Hooves (use 28-05-020, -001, -002, or -003 for Waste

The dust emissions in the modeling platform are not the same as the 2011NEIv2 emissions because the NEI paved and unpaved road dust emissions include a built-in precipitation reduction that is based on average meteorological data, which is at a coarser temporal and spatial resolution than the modeling platform meteorological adjustment. Due to this, in the platform the paved and unpaved road emissions, data used did not include any precipitation-based reduction. This allows the entire sector to be processed consistently so that the same grid-specific transport fractions and meteorological adjustments can be applied. Where states submitted afdust data, it was assumed that the state-submitted data were not met-adjusted and therefore the meteorological adjustments were still applied. Thus, it is possible that these sources may have been adjusted twice. Even with that possibility, air quality modeling shows that in general, dust is frequently overestimated in the air quality modeling results.

The total impacts of the transport fraction and meteorological adjustments for the 2011NEIv2 are shown in Table 2-7, where the starting inventory numbers include unadjusted paved and unpaved road dust, so they do not match the NEI values because those include a different type of adjustment. The amount of the reduction ranges from about 93% in New Hampshire to about 29% in Nevada.

Figure 2-1 shows the impact of each step of the adjustment for 2011. The reductions due to the transport fraction adjustments alone are shown at the top of Figure 2-1. The reductions due to the precipitation adjustments are shown in the middle of Figure 2-1. The cumulative emission reductions after both transport fraction and meteorological adjustments are shown at the bottom of Figure 2-1. 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.

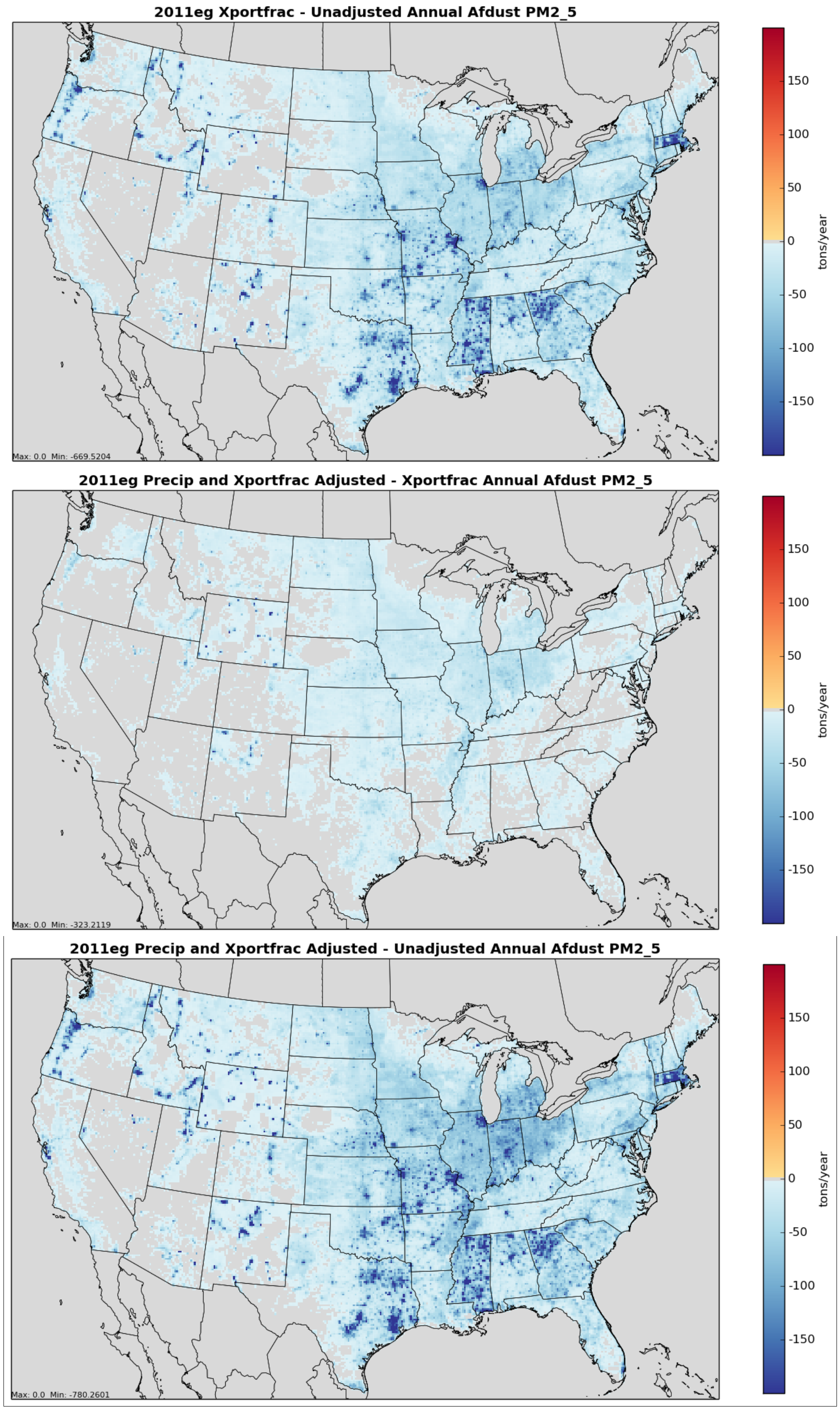
Table 2-7. Total Impact of Fugitive Dust Adjustments to Unadjusted 2011 Inventory

State	Unadjusted PM10	Unadjusted PM2_5	Change in PM10	Change in PM2_5	PM10 Reduction	PM2_5 Reduction
Alabama	378,874	47,158	-310,750	-38,597	82%	82%
Arizona	237,361	30,015	-78,519	-9,778	33%	33%
Arkansas	421,958	58,648	-305,611	-40,757	72%	69%
California	255,889	38,664	-119,035	-17,930	47%	46%
Colorado	244,630	40,421	-130,598	-20,991	53%	52%

State	Unadjusted PM10	Unadjusted PM2_5	Change in PM10	Change in PM2_5	PM10 Reduction	PM2_5 Reduction
Connecticut	29,067	4,393	-25,877	-3,912	89%	89%
Delaware	11,548	1,968	-8,219	-1,396	71%	71%
D.C.	2,115	337	-1,596	-254	75%	75%
Florida	292,797	39,637	-181,017	-24,333	62%	61%
Georgia	733,478	90,041	-593,644	-72,028	81%	80%
Idaho	432,116	49,294	-291,880	-32,897	68%	67%
Illinois	763,665	123,680	-472,806	-76,086	62%	62%
Indiana	603,152	85,151	-435,027	-60,660	72%	72%
Iowa	590,528	96,070	-339,349	-54,855	57%	57%
Kansas	747,242	118,726	-352,559	-54,760	47%	46%
Kentucky	199,744	29,496	-160,640	-23,511	80%	80%
Louisiana	236,787	35,730	-162,780	-24,086	69%	67%
Maine	50,547	7,016	-43,643	-6,078	86%	87%
Maryland	65,701	10,215	-49,481	-7,691	75%	75%
Massachusetts	205,561	22,444	-177,808	-19,370	86%	86%
Michigan	462,324	61,969	-353,225	-47,137	76%	76%
Minnesota	336,791	64,253	-217,036	-41,145	64%	64%
Mississippi	956,702	107,965	-782,249	-86,685	82%	80%
Missouri	1,063,992	130,995	-780,488	-94,576	73%	72%
Montana	385,541	50,583	-266,046	-33,521	69%	66%
Nebraska	591,457	85,206	-316,918	-45,198	54%	53%
Nevada	160,699	20,477	-47,147	-5,688	29%	28%
New Hampshire	25,540	3,766	-23,836	-3,515	93%	93%
New Jersey	24,273	5,412	-19,215	-4,255	79%	79%
New Mexico	924,497	95,871	-352,117	-36,344	38%	38%
New York	274,114	37,493	-236,431	-31,990	86%	85%
North Carolina	186,650	33,409	-146,918	-26,184	79%	78%
North Dakota	354,107	59,113	-218,630	-36,286	62%	61%
Ohio	414,902	64,609	-319,831	-49,298	77%	76%
Oklahoma	733,750	87,864	-385,344	-44,585	53%	51%
Oregon	348,093	40,596	-268,605	-30,516	77%	75%
Pennsylvania	208,246	30,344	-179,991	-26,158	86%	86%
Rhode Island	4,765	731	-3,628	-564	76%	77%
South Carolina	259,350	31,494	-198,175	-24,002	76%	76%
South Dakota	262,935	44,587	-155,938	-26,215	59%	59%
Tennessee	139,731	25,357	-107,964	-19,514	77%	77%
Texas	2,573,687	304,551	-1,278,053	-146,122	50%	48%

State	Unadjusted PM10	Unadjusted PM2_5	Change in PM10	Change in PM2_5	PM10 Reduction	PM2_5 Reduction
Utah	196,551	21,589	-113,837	-12,464	58%	58%
Vermont	67,690	7,563	-61,423	-6,855	91%	91%
Virginia	131,798	19,374	-108,700	-15,895	82%	82%
Washington	174,969	27,999	-99,720	-15,425	57%	55%
West Virginia	85,956	10,652	-79,745	-9,888	93%	93%
Wisconsin	239,851	41,669	-164,113	-28,542	68%	68%
Wyoming	434,090	45,350	-264,580	-27,467	61%	61%
Domain Total	**18,525,814**	**2,489,943**	**-11,790,743**	**-1,566,004**	**64%**	**63%**

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



2.2.2 Agricultural ammonia sector (ag)

The agricultural NH_3 (ag) sector includes livestock and agricultural fertilizer application emissions from the 2011NEIv2 nonpoint inventory. The livestock and fertilizer emissions in this sector are based only on the SCCs listed in Table 2-8 and Table 2-9. The "ag" sector includes all of the NH_3 emissions from fertilizer from the NEI. However, the "ag" sector does not include all of the livestock NH_3 emissions, as there are also a small amount of NH_3 emissions from livestock feedlots in the ptnonipm inventory (as point sources) in California (175 tons) and Wisconsin (125 tons).

Table 2-8. Livestock SCCs extracted from the NEI to create the ag sector

SCC	SCC Description*
2805001100	Beef cattle - finishing operations on feedlots (drylots);Confinement
2805001200	Beef cattle - finishing operations on feedlots (drylots);Manure handling and storage
2805001300	Beef cattle - finishing operations on feedlots (drylots);Land application of manure
2805002000	Beef cattle production composite; Not Elsewhere Classified
2805003100	Beef cattle - finishing operations on pasture/range; Confinement
2805007100	Poultry production - layers with dry manure management systems;Confinement
2805007300	Poultry production - layers with dry manure management systems;Land application of manure
2805008100	Poultry production - layers with wet manure management systems;Confinement
2805008200	Poultry production - layers with wet manure management systems;Manure handling and storage
2805008300	Poultry production - layers with wet manure management systems;Land application of manure
2805009100	Poultry production - broilers;Confinement
2805009200	Poultry production - broilers;Manure handling and storage
2805009300	Poultry production - broilers;Land application of manure
2805010100	Poultry production - turkeys;Confinement
2805010200	Poultry production - turkeys;Manure handling and storage
2805010300	Poultry production - turkeys;Land application of manure
2805018000	Dairy cattle composite;Not Elsewhere Classified
2805019100	Dairy cattle - flush dairy;Confinement
2805019200	Dairy cattle - flush dairy;Manure handling and storage
2805019300	Dairy cattle - flush dairy;Land application of manure
2805020000	Cattle and Calves Waste Emissions;Milk Total
2805020002	Cattle and Calves Waste Emissions:Beef Cows
2805021100	Dairy cattle - scrape dairy;Confinement
2805021200	Dairy cattle - scrape dairy;Manure handling and storage
2805021300	Dairy cattle - scrape dairy;Land application of manure
2805022100	Dairy cattle - deep pit dairy;Confinement
2805022200	Dairy cattle - deep pit dairy;Manure handling and storage
2805022300	Dairy cattle - deep pit dairy;Land application of manure
2805023100	Dairy cattle - drylot/pasture dairy;Confinement
2805023200	Dairy cattle - drylot/pasture dairy;Manure handling and storage
2805023300	Dairy cattle - drylot/pasture dairy;Land application of manure
2805025000	Swine production composite;Not Elsewhere Classified (see also 28-05-039, -047, -053)
2805030000	Poultry Waste Emissions;Not Elsewhere Classified (see also 28-05-007, -008, -009)
2805030003	Poultry Waste Emissions;Layers
2805030004	Poultry Waste Emissions;Broilers
2805030007	Poultry Waste Emissions;Ducks
2805030008	Poultry Waste Emissions;Geese
2805030009	Poultry Waste Emissions;Turkeys

SCC	SCC Description*
2805035000	Horses and Ponies Waste Emissions;Not Elsewhere Classified
2805039100	Swine production - operations with lagoons (unspecified animal age);Confinement
2805039200	Swine production - operations with lagoons (unspecified animal age);Manure handling and storage
2805039300	Swine production - operations with lagoons (unspecified animal age);Land application of manure
2805040000	Sheep and Lambs Waste Emissions;Total
2805045000	Goats Waste Emissions;Not Elsewhere Classified
2805045002	Goats Waste Emissions;Angora Goats
2805045003	Goats Waste Emissions;Milk Goats
2805047100	Swine production - deep-pit house operations (unspecified animal age);Confinement
2805047300	Swine production - deep-pit house operations (unspecified animal age);Land application of manure
2805053100	Swine production - outdoor operations (unspecified animal age);Confinement

* All SCC Descriptions begin "Miscellaneous Area Sources;Agriculture Production – Livestock"

Table 2-9. Fertilizer SCCs extracted from the NEI for inclusion in the "ag" sector

SCC	SCC Description*
2801700001	Anhydrous Ammonia
2801700002	Aqueous Ammonia
2801700003	Nitrogen Solutions
2801700004	Urea
2801700005	Ammonium Nitrate
2801700006	Ammonium Sulfate
2801700007	Ammonium Thiosulfate
2801700008	Other Straight Nitrate
2801700009	Ammonium Phosphates
2801700010	N-P-K (multi-grade nutrient fertilizers)
2801700011	Calcium Ammonium Nitrate
2801700012	Potassium Nitrate
2801700013	Diammonium Phosphate
2801700014	Monoammonium Phosphate
2801700015	Liquid Ammonium Polyphosphate
2801700099	Miscellaneous Fertilizers

* All descriptions include "Miscellaneous Area Sources; Agriculture Production – Crops; Fertilizer Application" as the beginning of the description.

2.2.3 Agricultural fires (agfire)

The agricultural fire (agfire) sector contains emissions from agricultural fires. These emissions were placed into the sector based on their SCC code. All SCCs starting with 28015 are included. 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. For more information on how emissions for agricultural fires were developed in the 2011NEIv2, see Section 5.2 of the 2011NEIv2 TSD.

2.2.4 Nonpoint source oil and gas sector (np_oilgas)

The nonpoint oil and gas (np_oilgas) sector contains onshore and offshore oil and gas emissions. The EPA estimated emissions for all counties with 2011 oil and gas activity data with the Oil and Gas Tool, and many S/L/T agencies also submitted nonpoint oil and gas data. The types of sources covered include drill rigs, workover rigs, artificial lift, hydraulic fracturing engines, pneumatic pumps and other devices, storage tanks, flares, truck loading, compressor engines, and dehydrators. Nonpoint oil and gas emissions for most states in the 2011v6.3 platform are consistent with those in the 2011NEIv2. For more information on the development of the oil and gas emissions in the 2011NEIv2, see Section 3.20 of the 2011NEIv2 TSD. The S/L/T agencies that submitted data used in 2011v6.3 include Texas, Oklahoma and Utah.

2.2.5 Residential wood combustion sector (rwc)

The residential wood combustion (rwc) sector includes residential wood burning devices such as fireplaces, fireplaces with inserts (inserts), free standing woodstoves, pellet stoves, outdoor hydronic heaters (also known as outdoor wood boilers), indoor furnaces, and outdoor burning in firepots and chimneas. 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 speaking, 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. For more information on the development of the residential wood combustion emissions, see Section 3.14 of the 2011NEIv2 TSD. The SCCs in the rwc sector are shown in Table 2-10.

Table 2-10. SCCs in the Residential Wood Combustion Sector (rwc)*

SCC	SCC Description
2104008100	SSFC;Residential;Wood;Fireplace: general
2104008210	SSFC;Residential;Wood;Woodstove: fireplace inserts; non-EPA certified
2104008220	SSFC;Residential;Wood;Woodstove: fireplace inserts; EPA certified; non-catalytic
2104008230	SSFC;Residential;Wood;Woodstove: fireplace inserts; EPA certified; catalytic
2104008300	SSFC;Residential;Wood;Woodstove: freestanding, general
2104008310	SSFC;Residential;Wood;Woodstove: freestanding, non-EPA certified
2104008320	SSFC;Residential;Wood;Woodstove: freestanding, EPA certified, non-catalytic
2104008330	SSFC;Residential;Wood;Woodstove: freestanding, EPA certified, catalytic
2104008400	SSFC;Residential;Wood;Woodstove: pellet-fired, general (freestanding or FP insert)
2104008420	SSFC;Residential;Wood;Woodstove: pellet-fired, EPA certified (freestanding or FP insert)
2104008510	SSFC;Residential;Wood;Furnace: Indoor, cordwood-fired, non-EPA certified
2104008610	SSFC;Residential;Wood;Hydronic heater: outdoor
2104008700	SSFC;Residential;Wood;Outdoor wood burning device, NEC (fire-pits, chimeas, etc)
2104009000	SSFC;Residential;Firelog;Total: All Combustor Types

* SSFC=Stationary Source Fuel Combustion

2.2.6 Other nonpoint sources sector (nonpt)

Stationary nonpoint sources that were not subdivided into the afdust, ag, np_oilgas, or rwc sectors were assigned to the “nonpt” sector. Locomotives and CMV mobile sources from the 2011NEIv2 nonpoint inventory are described in Section 2.4.1. There are too many SCCs in the nonpt sector to list all of them individually, but the types of sources in the nonpt sector include:

- stationary source fuel combustion, including industrial, commercial, and residential;
- chemical manufacturing;
- industrial processes such as commercial cooking, metal production, mineral processes, petroleum refining, wood products, fabricated metals, and refrigeration;
- 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;
- solvent utilization for asphalt application and roofing, and pesticide application;
- storage and transport of petroleum for uses such as portable gas cans, bulk terminals, gasoline service stations, aviation, and marine vessels;
- storage and transport of chemicals;
- waste disposal, treatment, and recovery via incineration, open burning, landfills, and composting;
- agricultural burning and orchard heating;
- miscellaneous area sources such as cremation, hospitals, lamp breakage, and automotive repair shops.

2.3 2011 onroad mobile sources (onroad)

Onroad mobile sources include emissions from motorized vehicles that are normally operated 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 between 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 moving along the roads). Except for California and Texas, all onroad emissions are generated using the SMOKE-MOVES emissions modeling framework that leverages MOVES-generated outputs (https://www.epa.gov/moves) and hourly meteorological data. For more information on the preparation of onroad mobile source emissions with SMOKE-MOVES, see the 2011v6.3 platform TSD.

There were no changes to onroad emissions or how they were processed for 2011en as compared to 2011el. The primary change to the onroad mobile source sector that were made for the *2011el* case concerns the penetration of E-85 fuels. Specifically, the percentage of E-85 in the activity data used to compute the EPA-default emissions for the 2011el case was updated to reflect actual usage of E-85 fuel, instead of reflecting activity from all "flex-fuel" vehicles which *could* use E-85. In the 2011ek case, 5.14 percent of all passenger vehicle VMT activity was allocated to E-85. That percentage reflects all flex-fuel vehicles on the road, whether or not those vehicles are actually using E-85. In the 2011el case, only 0.016 percent of total passenger vehicle VMT was allocated to E-85 fuel, reflecting the actual amount of E-85 fuel consumed. Table 2-11 shows the total onroad U.S. CAP emissions in the 2011v6.3 and updated platforms, rounded to the nearest thousand tons. The slight increase in some pollutants is due to the fact the E-85 emission factors are somewhat cleaner than those of regular gasoline. Thus, with the percent of E-85 reduced, the emissions increase slightly.

Table 2-11. Onroad CAP emissions in the 2011v6.3 and updated platforms (tons)

Pollutant	2011ek	2011el	% change
CO	25,380,000	25,992,000	2%
NH3	112,000	121,000	8%
NOX	5,609,000	5,708,000	2%
PM10	326,000	327,000	0%
PM2_5	188,000	189,000	1%
SO2	27,000	28,000	3%
VOC	2,657,000	2,713,000	2%

California onroad emissions were also updated for the *2023el* platform. The California onroad inventory includes updated vehicle type and road type distribution, so that they are estimated in a consistent way with the state-provided 2023 emissions. The vehicle type and road type distribution is based on the latest mapping between EMFAC Emissions Inventory Codes (EICs) and EPA source classification codes (SCCs), and unlike prior EIC-to-SCC mappings, distinguishes on-network emissions from off-network emissions.

2.3.1 Onroad (onroad)

For the continental U.S., EPA used a modeling framework that took into account the temperature sensitivity of the on-road emissions. Specifically, EPA used MOVES inputs for representative counties, vehicle miles traveled (VMT), vehicle population (VPOP), and hoteling data for all counties, along with tools that integrated the MOVES model with SMOKE. In this way, it was possible to take advantage of the gridded hourly temperature information available from meteorology modeling used for air quality modeling. The "SMOKE-MOVES" integration tool was developed by EPA in 2010 and is used for regional air quality modeling of onroad mobile sources.

SMOKE-MOVES requires that emission rate "lookup" tables be generated by MOVES which differentiate emissions by process (i.e., running, start, vapor venting, etc.), vehicle type, road type, temperature, speed, hour of day, etc. To generate the MOVES emission rates that could be applied across the U.S., EPA used an automated process to run MOVES to produce emission factors by temperature and speed for a series of "representative counties," to which every other county is mapped. Representative counties are used because it is impractical to generate a full suite of emission factors for the more than 3,000 counties in the United States. Representative counties, for which emission factors are generated are selected according to their state, elevation, fuels, age distribution, ramp fraction, and inspection & maintenance programs. Each county is then mapped to a representative county based on its similarity with the representative county with respect to those attributes. For the 2011v6.3 platform, there are 285 representative counties.

Once representative counties have been identified, emission factors are generated with MOVES for each representative county and for each "fuel month" – typically a summer month and a winter month. Using the MOVES emission rates, SMOKE selects appropriate emissions rates for each county, hourly temperature, SCC, and speed bin and multiplies the emission rate by activity: VMT (vehicle miles travelled), VPOP (vehicle population)), or HOTELING (hours of extended idle) to produce emissions. These calculations were done for every county and grid cell in the continental U.S. for each hour of the year.

The SMOKE-MOVES process for creating the model-ready emissions consists of the following steps:

1) Determine which counties will be used to represent other counties in the MOVES runs.
2) Determine which months will be used to represent other month's fuel characteristics.
3) Create MOVES inputs needed only by MOVES. MOVES requires county-specific information on vehicle populations, age distributions, and inspection-maintenance programs for each of the representative counties.
4) Create inputs needed both by MOVES and by SMOKE, including temperatures and activity data.
5) Run MOVES to create emission factor tables for the temperatures found in each county.
6) Run SMOKE to apply the emission factors to activity data (VMT, VPOP, and HOTELING) to calculate emissions based on the gridded hourly temperatures in the meteorological data.
7) Aggregate the results to the county-SCC level for summaries and quality assurance.

The onroad emissions are processed in four processing streams that are merged together into the onroad sector emissions after processing:

- rate-per-distance (RPD) uses VMT as the activity data plus speed and speed profile information to compute on-network emissions from exhaust, evaporative, permeation, refueling, and brake and tire wear processes;
- rate-per-vehicle (RPV) uses vehicle population (VPOP) activity data to compute off-network emissions from exhaust, evaporative, permeation, and refueling processes;
- rate-per-profile (RPP) uses VPOP activity data to compute off-network emissions from evaporative fuel vaper venting including hot soak (immediately after a trip) and diurnal (vehicle parked for a long period) emissions; and
- rate-per-hour (RPH) uses hoteling hours activity data to compute off-network emissions for idling of long-haul trucks from extended idling and auxiliary power unit process.

The onroad emissions inputs are similar to the emissions in the onroad data category of the 2011NEIv2, described in more detail in Section 4.6 of the 2011NEIv2 TSD. Specifically, the 2011v6.3 platform and the 2011NEIv2 have nearly identical:

- MOVES County databases (CDBs) including Low Emission Vehicle table dated 20140903
- Representative counties (i.e., 285RepCos2011_M2014_20151208)
- Fuel months
- Meteorology
- Activity data (VMT, VPOP, speed, HOTELING)

SMOKE-MOVES are both run using a detailed set of processes, but in the NEI emissions were aggregated into two modes: refueling and all other modes. In addition, the NEI SCCs were aggregated over roads to all parking and all road emissions. The list of modes (or aggregate processes) used in the v6.2 platform and the corresponding MOVES processes mapped to them are listed in Table 2-12.

Table 2-12. Onroad emission aggregate processes

Aggregate process	**Description**	**MOVES process IDs**
40	All brake and tire wear	9;10
53	All extended idle exhaust	17;90
62	All refueling	18;19
72	All exhaust and evaporative except refueling and hoteling	1;2;11;12;13;15;16
91	Auxiliary Power Units	91

One reason that brake and tire wear was split out from the other processes was to allow for better modeling of the impacts of electric vehicles in future years, since these vehicles still have brake and tire wear emissions, but do not have exhaust, evaporative, or refueling emissions. For more detailed information on methods used to develop the onroad emissions and input data sets and on running SMOKE-MOVES, see the 2011NEIv2 TSD.

The California and Texas onroad emissions were created through a hybrid approach of combining state-supplied annual emissions with EPA-developed SMOKE-MOVES runs. Through this approach, the platform was able to reflect the unique rules in California and Texas, while leveraging the more detailed SCCs and the highly resolved spatial patterns, temporal patterns, and speciation from SMOKE-MOVES. The basic steps involved in temporally allocating onroad emissions from California and Texas based on SMOKE-MOVES results were:

1) Run CA and TX using EPA inputs through SMOKE-MOVES to produce hourly 2011 emissions hereafter known as "EPA estimates." These EPA estimates for CA and TX are run in a separate sector called "onroad_catx."
2) Calculate ratios between state-supplied emissions and EPA estimates[2]. For California, these were calculated for each county/SCC/pollutant combination, except with all road types summed together because California's emissions did not provide data by road type, and with E-85 emissions combined with gasoline because separate emissions were not provided for E-85. For Texas, the ratios were calculated for each county/SCC/pollutant combination, including by road type, but also with E-85 combined with gasoline.
3) Create an adjustment factor file (CFPRO) that includes EPA-to-state estimate ratios.
4) Rerun CA and TX through SMOKE-MOVES using EPA inputs and the new adjustment factor file.

Through this process, adjusted model-ready files were created that sum to annual totals from California and Texas, but have the temporal and spatial patterns reflecting the highly resolved meteorology and SMOKE-MOVES. After adjusting the emissions, this sector is called "onroad_catx_adj." Note that in emission summaries, the emissions from the "onroad" and "onroad_catx_adj" sectors are summed and designated as the emissions for the onroad sector.

An additional step was taken for the refueling emissions. Colorado submitted point emissions for gasoline refueling for some counties[3]. For these counties, the EPA zeroed out the onroad estimates of gasoline refueling (SCC 2201*62) so that the states' point emissions would take precedence. The onroad refueling emissions were zeroed out using the adjustment factor file (CFPRO) and Movesmrg.

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[2] These ratios were created for all matching pollutants. These ratios were duplicated for all appropriate modeling species. For example, EPA used the NO_X ratio for NO, NO_2, HONO and used the $PM_{2.5}$ ratio for PEC, PNO_3, POC, PSO_4, etc. (For more details on NO_X and PM speciation, see Sections 3.2.2, and 3.2.3. For VOC model-species, if there was an exact match (e.g., BENZENE), the EPA used that HAP pollutant ratio. For other VOC-based model-species that didn't exist in the NEI inventory, the EPA used VOC ratios.

[3] There were 53 counties in Colorado that had point emissions for gasoline refueling. Outside Colorado, it was determined that refueling emissions in the 2011 NEIv2 point did not significantly overlap the refueling emissions in onroad.

2.4 2011 nonroad mobile sources (cmv_c1c2, cmv_c3, 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, Category 3 Commercial Marine Vessels (cmv_c1c2, cmv_c3)

In the 2011el case, the cmv sector contained all Category 1, 2 and 3 CMV emissions in U.S. waters. In the 2011en case, the CMV emissions are split between the cmv_c1c2 and the cmv_c3 sectors but the total emissions are essentially unchanged. In the NEI emissions in these sectors are annual and at the county-SCC resolution and based on the 2011NEIv2. The NEI CMV emissions use state-submitted values and EPA-developed emissions in areas where states did not submit. The emissions include the offshore portion of the C1 and C2 commercial marine sources, including fishing vessels and oil rig support vessels in the Gulf of Mexico. Emissions that occur outside of state waters are not assigned to states. For more information on CMV sources in the NEI, see Section 4.3 of the 2011NEIv2 TSD.

Table 2-13. 2011NEIv2 SCCs extracted for the cmv sector

SCC	Sector	Description: Mobile Sources prefix for all
2280002100	cmv	Marine Vessels; Commercial; Diesel; Port
2280002200	cmv	Marine Vessels; Commercial; Diesel; Underway
2280003100	cmv	Marine Vessels, Commercial;Residual;Port emissions
2280003200	cmv	Marine Vessels, Commercial;Residual;Underway emissions
2280004000	cmv	Marine Vessels, Commercial;Gasoline;Total, All Vessel Types

In 2011el, the cmv sector was updated to incorporate updated CMV emissions in California so that they are estimated in a consistent way with the state-provided 2023 emissions. A comparison of the 2011NEIv2 and the updated emissions for California is shown in Table 2-14. In 2011en, these updated emissions are found in the cmv_c1c2 sector because in California, the ships are required to use cleaner diesel fuel in state waters instead of the residual fuel assumed for C3 ships in most areas.

Table 2-14. California CMV CAP emissions in the original and updated 2011v6.3 platforms (tons)

Pollutant	2011ek	2011el
CO	6,572	5,082
NH3	8	6
NOX	21,622	21,055
PM10	495	808
PM2_5	462	752
SO2	255	1,827
VOC	1,675	1,375

Category 3 (C3) CMV sources run on residual oil, are consistent with those in the 2011NEIv2, and use the SCCs 2280003100 and 2280003200 for port and underway emissions, respectively. In 2011en, the Category 3 (C3) CMV emissions were reallocated from area to point sources so that emissions could be assigned to layers higher than layer 1, but the emissions totals are the same as those in 2011el. The point sources in the cmv_c3 inventory align with the point sources in the Emissions Control Area (ECA) inventory (EPA, 2015b). A set of fixed stack parameters were assigned to every CMV point source

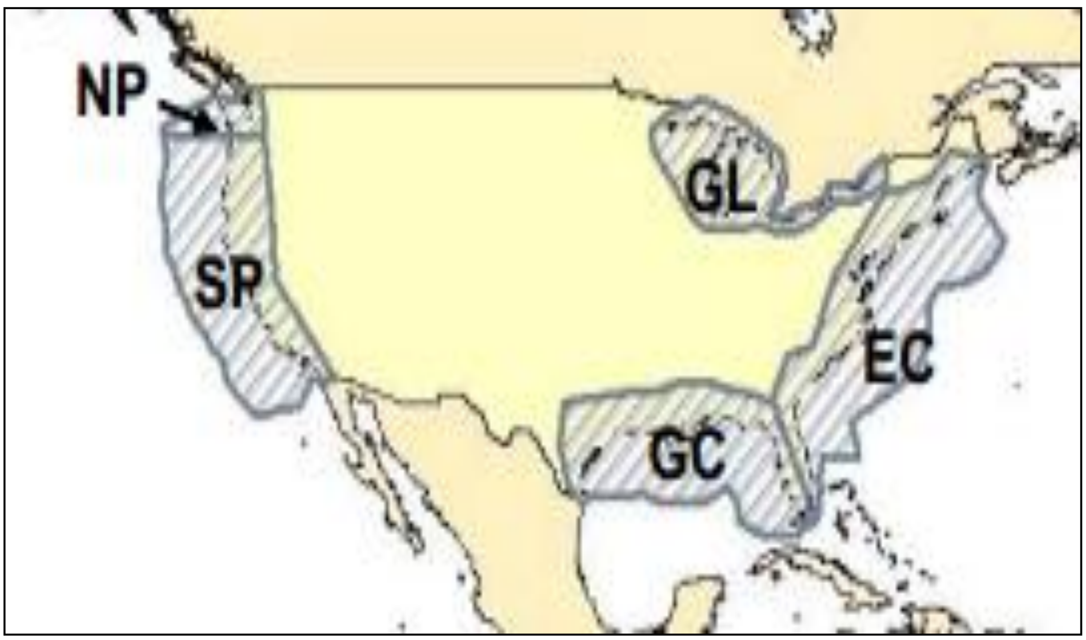
created in this process: stack height of 20 m, stack diameter of 0.8 m, stack velocity of 25 m/s, and a stack temperature of 282°C.

The base-year ECA inventory is 2002 and consists of these CAPs: PM_{10}, $PM_{2.5}$, CO, CO_2, NH_3, NO_X, SO_X (assumed to be SO_2), and hydrocarbons (assumed to be VOC). The EPA developed regional growth (activity-based) factors that were applied to create the 2011 inventory from the 2002 data. These growth factors are provided in Table 2-15. The geographic regions listed in the table are shown in Figure 2-2. * The East Coast and Gulf Coast regions were divided along a line roughly through Key Largo (longitude 80° 26' West). Technically, the Exclusive Economic Zone (EEZ) FIPS are not really "FIPS" state-county codes, but are treated as such in the inventory and emissions processing.

Table 2-15. Growth factors to project the 2002 ECA-IMO inventory to 2011

Region	**EEZ FIPS**	**NO_X**	**PM_{10}**	**$PM_{2.5}$**	**VOC**	**CO**	**SO_2**
East Coast (EC)	85004	1.301	0.500	0.496	1.501	1.501	0.536
Gulf Coast (GC)	85003	1.114	0.428	0.423	1.288	1.288	0.461
North Pacific (NP)	85001	1.183	0.467	0.458	1.353	1.353	0.524
South Pacific (SP)	85002	1.367	0.525	0.521	1.565	1.562	0.611
Great Lakes (GL)	n/a	1.072	0.394	0.390	1.177	1.176	0.415
Outside ECA	98001	1.341	1.457	1.457	1.457	1.457	1.457

Figure 2-2. Illustration of regional modeling domains in ECA-IMO study



The emissions were converted to SMOKE point source inventory format allowing for the emissions to be allocated to modeling layers above the surface layer. As described in the paper, the ASCII raster dataset was converted to latitude-longitude, mapped to state/county FIPS codes that extended up to 200 nautical miles (nm) from the coast, assigned stack parameters, and monthly ASCII raster dataset emissions were used to create monthly temporal profiles. All non-US, non-EEZ emissions (i.e., in waters considered outside of the 200 nm EEZ and, hence, out of the U.S. and Canadian ECA-IMO controllable domain) were simply assigned a dummy state/county FIPS code=98001, and were projected to year 2011 using the “Outside ECA” factors in Table 2-15.

The assignment of U.S. state/county FIPS codes was restricted to state-federal water boundaries data from the Mineral Management Service (MMS) that extend approximately 3 to 10 nm off shore. Emissions outside the 3 to 10 mile MMS boundary, but within the approximately 200 nm EEZ boundaries in Figure 2-2, were projected to year 2011 using the same regional adjustment factors as the U.S. emissions; however, the state/county FIPS codes were assigned as “EEZ” codes and those emissions processed in the “othpt” sector (see Section 2.5.1). Note that state boundaries in the Great Lakes are an exception, extending through the middle of each lake such that all emissions in the Great Lakes are assigned to a U.S. county or Ontario. This holds true for Midwest states and other states such as Pennsylvania and New York. The classification of emissions to U.S. and Canadian FIPS codes is needed to avoid double-counting of C3 CMV U.S. emissions in the Great Lakes because, as discussed in the previous section, all CMV emissions in the Midwest RPO are processed in the “cmv” sector.

The SMOKE-ready data have been cropped from the original ECA-IMO entire northwestern quarter of the globe to cover only the large continental U.S. 36-km “36US1” air quality model domain, the largest domain used by EPA in recent years[4]. The original ECA-IMO inventory did not delineate between ports and underway emissions (or other C3 modes such as hoteling, maneuvering, reduced-speed zone, and idling). However, a U.S. ports spatial surrogate dataset was used to assign the ECA-IMO emissions to ports and underway SCCs 2280003100 and 2280003200, respectively.

To prepare the cmv_c3 inventory for 2011en, in cases where counties and SCCs overlap between the 2011NEIv2 cmv_c3 inventory and the 2011 ECA point inventory, county to point allocation fractions by county and SCC were derived from the 2011 ECA point inventory. The county allocation fractions were calculated by dividing the 2011 ECA annual $PM_{2.5}$ emissions for each point source within a county by the total 2011 ECA $PM_{2.5}$ emissions for that county. These fractions were then applied to the cmv_c3 area county level 2011NEIv2 inventory emissions by associated county and SCC to get cmv_c3 emissions by county, SCC, and point source in point FF10 inventory format. The locations of the ECA point sources were carried forward into the cmv_c3 point inventory for each source that was allocated to a 2011NEIv2 cmv_c3 county.

Where the cmv_c3 area county-level inventory had emissions in counties not contained in the 2011 ECA point inventory, fallback factors by source type, port and underway, were applied to spatially allocate the emissions. These fallback methods produce cmv_c3 point sources at a 12km resolution based on polygons or surrogates. The fallback port point allocations were calculated based on the 2014 NATA v1 port polygons. Port activity was estimated by county using the fraction of PM2_5 emissions (SCC 2280003100) assigned to each port within a county. To get a total emissions allocation fraction from county to a 12US2 (see Figure 3-1) grid cell centroid the county activity fraction was multiplied by the fraction of area that a 12US2 grid cell overlaps each county port shape. Surrogate 801 was used as a tertiary fallback when port polygons were not available for a county with cmv_c3 port emissions. The underway point fallbacks were calculated from surrogate 806. County emissions (SCC 2280003200) were assigned to 12US2 grid cell centroids based on the county to grid cell surrogate fractions in surrogate 806. The underway surrogate fallback methodology is comparable to the surrogate 801 fallback used for port emissions.

[4] The extent of the “36US1” domain is similar to the full geographic region shown in Figure 3-1. Note that this domain is not specifically used in this 2011 platform, although spatial surrogates that can be used with it are provided.

2.4.2 Railroad sources: (rail)

The rail sector includes all locomotives except for railway maintenance locomotives. Railway maintenance emissions are included in the nonroad sector. The yard locomotives are included in the ptnonipm sector. For more information on locomotive sources in the NEI, see Section 4.4 of the 2011NEIv2 TSD.

Table 2-16. 2011NEIv2 SCCs extracted for the starting point in rail development

SCC	Sector	Description: Mobile Sources prefix for all
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

2.4.3 Nonroad mobile equipment sources: (nonroad)

The nonroad equipment emissions are equivalent to the emissions in the nonroad data category of the 2011NEIv2, with the exception that the modeling platform emissions also include monthly totals. All nonroad emissions are compiled at the county/SCC level. NMIM (EPA, 2005) creates the nonroad emissions on a month-specific basis that accounts for temperature, fuel types, and other variables that vary by month. The nonroad sector includes monthly exhaust, evaporative and refueling emissions from nonroad engines (not including commercial marine, aircraft, and locomotives) that EPA derived from NMIM for all states except California and Texas. Additional details on the development of the 2011NEIv2 nonroad emissions are available in Section 4.5 the 2011NEIv2 TSD.

California year 2011 nonroad emissions were submitted to the 2011NEIv2 and are also documented in a staff report (ARB, 2010a). The nonroad sector emissions in California were developed using a modular approach and include all rulemakings and updates in place by December 2010. These emissions were developed using Version 1 of the CEPAM, which supports various California off-road regulations such as in-use diesel retrofits (ARB, 2007), Diesel Risk-Reduction Plan (ARB, 2000) and 2007 State Implementation Plans (SIPs) for the South Coast and San Joaquin Valley air basins (ARB, 2010b).

The CARB-supplied nonroad annual inventory emissions values were converted to monthly values by using the aforementioned EPA NMIM monthly inventories to compute monthly ratios by county, SCC7 (fuel, engine type, and equipment type group), mode, and pollutant. The SCC7 ratios were used because the SCCs in the CARB inventory did not align with many of the SCCs in EPA NMIM inventory. By aggregating up to SCC7, the two inventories had a more consistent coverage of sources. Some VOC emissions were added to California to account for situations when VOC HAP emissions were included in the inventory, but there were no VOC emissions. These additional VOC emissions were computed by summing benzene, acetaldehyde, and formaldehyde for the specific sources.

Texas year 2011 nonroad emissions were also submitted to the NEI. The 2011NEIv2 nonroad annual inventory emissions values were converted to monthly values by using EPA's NMIM monthly inventories to compute monthly ratios by county, SCC7, mode, and poll[5].

2.5 "Other Emissions": Emissions from Non-U.S. sources

The emissions from Canada, Mexico, and U.S. offshore drilling platforms are included as part of four emissions modeling sectors: othpt, othar, othafdust, and othon. The "oth" refers to the fact that these emissions are usually "other" than those that exist in areas that use the U.S. state-county geographic Federal Information Processing Standards (FIPS) for county locations, while the remaining characters provide the SMOKE source types: "pt" for point; "ar" for "area and nonroad mobile;" and "on" for onroad mobile. The changes in the 2011el case for emissions in the entire country of Mexico for each sector are shown in Table 2-17 and Table 2-18 shows the changes for Canada. The reasons for the changes are explained in the sub-sections that follow.

Table 2-17. Mexico CAP emissions in the 2011v6.3 and updated platforms (tons)

	CO	NH3	NOX	PM10	PM2_5	SO2	VOC
2011ek othpt	694,173	31,569	606,442	233,158	160,911	2,393,790	290,676
2011el othpt	683,482	32,773	651,521	241,496	168,144	2,276,770	303,905
2011ek othar	3,081,442	852,041	721,690	628,158	454,385	47,290	3,488,075
2011el othar	2,579,614	875,696	706,612	574,293	404,291	44,083	3,564,949
2011ek othon	23,220,743	53,309	1,650,448	16,582	12,002	25,449	2,159,346
2011el othon	5,887,937	9,170	1,411,830	57,782	43,576	22,470	541,390

Table 2-18. Canada CAP emissions in 2011el vs 2011en (tons)

Case and Sector	CO	NH3	NOx	PM10	PM2.5	SO2	VOC
2011el othafdust				6,018,802	938,015		
2011en othafdust				8,573,732	1,643,832		
2011el othar	4,151,170	468,863	667,282	244,765	199,352	156,765	1,285,976
2011en othar	3,265,982	509,752	768,873	301,445	259,832	86,284	1,243,806
2011el othon	4,262,403	24,226	506,407	23,572	18,019	2,381	262,908
2011en othon	2,259,190	8,884	505,059	29,840	22,772	1,673	205,535
2011el othpt	1,329,036	20,987	958,229	165,389	69,195	1,347,075	979,932
2011en othpt	1,405,817	19,240	833,998	133,709	57,660	1,235,619	963,504

2.5.1 Point Sources from Offshore C3 CMV, Drilling platforms, Canada and Mexico (othpt)

The othpt sectors includes offshore oil and gas drilling platforms that are beyond U.S. state-county boundaries in the Gulf of Mexico and point sources for Canada and Mexico. Point sources in Mexico were compiled based on the Inventario Nacional de Emisiones de Mexico, 2008 (ERG, 2014a). The 2011ek case used 2008 estimates, but in 2011el, the emissions were projected to the year 2011 by

[5] If there was no match at county/SCC7/mode/poll, the allocation would fall back to state/SCC7/mode/poll. If that did not find a match, then state/SCC7 was used. For a few situations, that would also fail to match and the monthly emissions were allocated with a similar SCC7.

interpolating between 2008 emissions and projected 2014 emissions (ERG, 2016). The point source emissions in the 2008 inventory were converted to English units and into the FF10 format that could be read by SMOKE, missing stack parameters were gapfilled using SCC-based defaults, and latitude and longitude coordinates were verified and adjusted if they were not consistent with the reported municipality. Note that there are no explicit HAP emissions in this inventory.

The point source offshore oil and gas drilling platforms from the 2011NEIv2 were used. For Canadian point sources, 2013 emissions provided by Environment Canada were used. Temporal profiles and speciated emissions were also provided. Note that Canadian CMV emissions are in the othar sector and are not processed as point sources.

C3 CMV emissions assigned to either the Exclusive Economic Zone (EEZ) (defined as those emissions beyond the U.S. Federal waters approximately 3-10 miles offshore, and extending to about 200 nautical miles from the U.S. coastline) or to outlying waters beyond the EEZ, which were part of the othpt sector in the 2011el case, were moved to the *cmv_c3* sector for the 2011en case.

2.5.2 Area and Nonroad Mobile Sources from Canada and Mexico (othar, othafdust)

The othar sector includes nonpoint and nonroad mobile source emissions in Canada and Mexico. The Canadian sources were updated to month-specific year-2013 emissions provided by Environment Canada, including the Canadian C3 CMV emissions.

For the original 2011ek case, area and nonroad mobile sources in Mexico for 2008 were compiled the Inventario Nacional de Emisiones de Mexico, 2008 (ERG, 2014a). The 2008 emissions were quality assured for completeness, SCC assignments were made when needed, the pollutants expected for the various processes were reviewed, and adjustments were made to ensure that PM_{10} was greater than or equal to $PM_{2.5}$. The resulting inventory was written using English units to the nonpoint FF10 format that could be read by SMOKE and projected to the year 2014 (ERG, 2016). For the 2011el case, the area and nonroad emissions were linearly interpolated to represent the year 2011. Also in 2011el, wildfire and agricultural fire emissions were removed from the Mexico nonpoint inventory to prevent double counting emissions with the new ptfire_mxca sector. Note that unlike the U.S. inventories, there are no explicit HAPs in the nonpoint or nonroad inventories for Canada and Mexico and, therefore, all HAPs are created from speciation. For the 2011en case, an updated population surrogate was added to spatially allocate Mexican area and nonroad sources in the 2023en case.

The othafdust sector includes nonpoint fugitive dust source emissions for Canada only. For 2011en, Environment Canada provided an updated year 2013 inventory for the othafdust sector for this updated modeling platform. The othafdust inventory consisted of an annual inventory at the province resolution that was adjusted using export fraction and precipitation data to generate hourly, gridded emissions for this sector.

2.5.3 Onroad Mobile Sources from Canada and Mexico (othon)

The othon sector includes onroad mobile source emissions in Canada and Mexico. The Canadian sources were updated in the 2023en case using month-specific year-2013 emissions provided by Environment Canada. Note that unlike the U.S. inventories, there are no explicit HAPs in the onroad inventories for Canada and therefore all HAPs are created from speciation.

For the 2011en case, an updated population surrogate was used to spatially allocate onroad sources in Mexico. For the earlier 2011el case, the onroad mobile sources in Mexico were updated to 2011 levels based on a run of MOVES-Mexico for 2011. The development of the 2011 onroad inventory for Mexico is described in Development of Mexico Emission Inventories for the 2014 Modeling Platform (ERG, 2016). The following information on how the 2011 onroad inventory was developed is from that document which also includes a comparison of the updated emissions with other recent inventories or onroad mobile sources in Mexico:

> "Under the sponsorship of USAID, through the Mexico Low Emissions Development Program (MLED), in early 2016 ERG adapted MOVES2014a (https://www.epa.gov/moves) to Mexico (USAID, 2016). As with the U.S. version of the model, "MOVES-Mexico" has the capability to produce comprehensive national vehicle emission inventories, and to provide a framework for users to create detailed regional emission inventories and microscale emission assessments. The approach for adapting MOVES was determined based on Mexico's available vehicle fleet and activity data, and to account for significant differences in vehicle emissions standards between Mexico and the U.S. To aid this, the Mexican government agency National Institute of Ecology and Climate Change (*Instituto Nacional de Ecología y Cambio Climático* or INECC) provided data for fundamental model inputs such as vehicle kilometers travelled, vehicle population, age distribution, and emission standards. INECC also provided data on over 250,000 roadside remote sensing device (RSD) measurements across 24 Mexican cities, which were analyzed to help calibrate MOVES-Mexico emission rates. The data from INECC and other government sources have been synthesized to create a national Mexico-specific MOVES database that can be used directly with MOVES2014a as an alternate default database, replacing the U.S. default database that comes with the U.S. model download. MOVES-Mexico can estimate vehicle emissions for calendar years 1990 through 2050 at the nation, state or municipio (county-equivalent) level."
>
> …
>
> "[The 2011] on-road mobile source emissions inventory was developed using output from MOVES-Mexico. Emissions were generated for each municipio; for a typical weekday and typical weekend by month; for the pollutant set used for the U.S. NEI. Total annual emissions were compiled into a single Flat File 10 (FF10) format file. MOVES-Mexico was run in default mode, which reflects Mexico-specific data for key inputs such as vehicle population, VMT, fuels, inspection and maintenance (I/M) programs and Mexico's emission standards."
>
> …
>
> "The outputs of the MOVES-Mexico runs were processed to obtain total annual emissions by pollutant and EPA Source Classification Code (SCC) and compiled into a single FF10 format file. This involved looping through the output databases for all the individual municipios; extracting the emissions for a particular pollutant from both the evaporative and non-evaporative output databases; and summing the emissions across all hours to obtain total emissions by day type (weekend and weekday) for each month. The total monthly emissions were then calculated as the product of the daily weekend (weekday) emissions and the number of weekends (weekdays) in each month. The monthly emissions were then summed to obtain annual emissions and converted to U.S. short tons."

2.6 U.S. Fires (ptfire)

In the 2011v6.3 platform, both the wildfires and prescribed burning emissions are contained in the ptfire sector. Fire emissions are specified at geographic coordinates (point locations) and have daily emissions values. The ptfire sectors exclude agricultural burning and other open burning sources that are included in the nonpt sector. Emissions are day-specific and include satellite-derived latitude/longitude of the fire's origin and other parameters associated with the emissions such as acres burned and fuel load, which allow estimation of plume rise. Emissions for the SCCs listed in Table 2-21 are treated as point sources and are consistent with the fires stored in the Events data category of the 2011NEIv2. For more information on the development of the 2011NEIv2 fire inventory, see Section 5.1 of the 2011NEIv2 TSD.

Table 2-19. 2011 Platform SCCs representing emissions in the ptfire modeling sectors

SCC	**SCC Description***
2810001000	Other Combustion; Forest Wildfires; Total
2810001001	Other Combustion; Forest Wildfires; Wildland fire use
2811015000	Other Combustion-as Event; Prescribed Burning for Forest Management; Total

* The first tier level of the SCC Description is "Miscellaneous Area Sources"

The point source day-specific emission estimates for 2011 fires rely on SMARTFIRE 2 (Sullivan, et al., 2008), which uses the National Oceanic and Atmospheric Administration's (NOAA's) Hazard Mapping System (HMS) fire location information as input. Additional inputs include the CONSUMEv3.0 software and the Fuel Characteristic Classification System (FCCS) fuel-loading database to estimate fire emissions from wildfires and prescribed burns on a daily basis. The method involves the reconciliation of ICS-209 reports (Incident Status Summary Reports) with satellite-based fire detections to determine spatial and temporal information about the fires. A functional diagram of the SMARTFIRE 2 process of reconciling fires with ICS-209 reports is available in the documentation (Raffuse, et al., 2007). Once the fire reconciliation process is completed, the emissions are calculated using the U.S. Forest Service's CONSUMEv3.0 fuel consumption model and the FCCS fuel-loading database in the BlueSky Framework (Ottmar, et al., 2007).http://www.fs.fed.us/pnw/fera/research/smoke/consume/index.shtml

SMARTFIRE 2 estimates were used directly for all states except Georgia and Florida. For Georgia, the satellite-derived emissions were removed from the ptfire inventory and replaced with a separate state-supplied ptfire inventory. Adjustments were also made to Florida as described in Section 5.1.4 of the 2011NEIv2 TSD. These changes made the data in the ptfire inventory consistent with the data in the 2011NEIv2.

An update originally incorporated in the 2011v6.2 platform was to split fires over 20,000 acres into the respective grid cells that they overlapped. The idea of this was to prevent all emissions from going into a single grid cell when, in reality, the fire was more dispersed than a single point. The large fires were each projected as a circle over the area centered on the specified latitude and longitude, and then apportioned into the grid cells they overlapped. The area of each of the "subfires" was computed in proportion to the overlap with that grid cell. These "subfires" were given new names that were the same as the original, but with "_a", "_b", "_c", and "_d" appended as needed. The FIPS state and county codes and fire IDs for the fifteen fires apportioned to multiple grid cells are shown in Table 2-20.

Table 2-20. Large fires apportioned to multiple grid cells

County FIPS	Fire ID
32007	SF11C1774898
32007	SF11C1775252
32013	SF11C1774993
35027	SF11C1760072
35027	SF11C1760460

County FIPS	Fire ID
46065	SF11C1503125
48003	SF11C1718109
48081	SF11C1742329
48125	SF11C1749358
48243	SF11C1738273
48243	SF11C1747162
48353	SF11C1759082
48371	SF11C1750272
48415	SF11C1742358
56013	SF11C1791126

2.7 Non-U.S. Fires (ptfire_mxca)

The development of the U.S. fires in the ptfire sector is described in the 2011v6.3 TSD (EPA, 2016a). The SCCs for this sector are listed in Table 2-21. In the 2011el case update to the 2011v6.3 platform, a new sector of fire emissions in Mexico and Canada was added. Note that unlike the other sectors, the ptfire_mxca sector emissions were processed with SMOKE 4.0 because it has better support for processing FF10-formatted fire inventories. Fire emissions are specified at geographic coordinates (point locations) and have daily emissions values. Emissions are day-specific and include satellite-derived latitude/longitude of the fire's origin and other parameters associated with the emissions such as acres burned and fuel load, which allow estimation of plume rise.

Table 2-21. 2011 Platform SCCs representing emissions in the ptfire modeling sectors

SCC	**SCC Description***
2810001000	Other Combustion; Forest Wildfires; Total
2810001001	Other Combustion; Forest Wildfires; Wildland fire use
2811015000	Other Combustion-as Event; Prescribed Burning for Forest Management; Total

* The first tier level of the SCC Description is "Miscellaneous Area Sources."

The 2011 fire inventory for Canada was obtained from Environment Canada. This point source fire inventory was generated using the Canadian Wildland Fire Information System (CWFIS) (http://cwfis.cfs.nrcan.gc.ca). Area burned and daily fire spread estimates are derived from satellite products. CWFIS integrates multi-source data for national-level products. These data include a fuels database, fire weather, topography, moisture content, and fire type and duration information. CWFIS also uses the BlueSky module Fire Emission Production Simulator (FEPS) (Anderson, 2004) to generate day-specific SMOKE-ready emissions data. The CWFIS fire inventory can also include agricultural burns, however all CWFIS fires are labeled with SCC 2810001000. The output format from CWFIS currently only supports older versions of SMOKE. The CWFIS data were converted to SMOKE FF10 format for use in this modeling effort.

The Fire INventory from NCAR (FINN) (Wiedinmyer, 2011) version 1.5 was used to supply a fire inventory for Mexico. FINN (https://www2.acom.ucar.edu/modeling/finn-fire-inventory-ncar) provides daily, 1 km resolution, global estimates of the trace gas and particle emissions from open burning of biomass, which includes wildfire, agricultural fires, and prescribed burning and does not include biofuel use and trash burning. This day-specific FINN data was downloaded from http://bai.acom.ucar.edu/Data/fire/ and was converted to SMOKE FF10 format for this modeling effort.

2.8 Biogenic emissions (beis)

Biogenic emissions were computed based on the same 11g version of the 2011 meteorology data used for the air quality modeling, and were developed using the Biogenic Emission Inventory System version 3.61 (BEIS3.61) within SMOKE. The landuse input into BEIS3.61 is the BELD version 4.1 which is based on an updated version of the USDA-USFS Forest Inventory and Analysis (FIA) vegetation speciation based data from 2001 to 2014 from the FIA version 5.1. After the 2011el/2023el cases, additional quality assurance of the BELD4.1 resulted in minor corrections to the landuse data in three states including Washington, Texas and Florida. These minor corrections were implemented in the 2011en/2023en modeling cases and representing about less than 1% reduction in biogenic emissions in these three states. For more information on biogenic emissions, see the original 2011v6.3 platform TSD (EPA, 2016a).

BEIS3.61 has some important updates from BEIS 3.14. These include the incorporation of Version 4.1 of the Biogenic Emissions Land use Database (BELD4) for the 2011v6.3 platform, and the incorporation of a canopy model to estimate leaf-level temperatures (Pouliot and Bash, 2015). BEIS3.61 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., 2015). 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 to convert WRF outputs to CMAQ inputs are shown in Table 2-22.

Table 2-22. Meteorological variables required by BEIS 3.61

Variable	Description
LAI	leaf-area index
PRSFC	surface pressure
Q2	mixing ratio at 2 m
RC	convective precipitation per met TSTEP
RGRND	solar rad reaching sfc
RN	nonconvective precipitation per met TSTEP
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

BELD version 4.1 is based on an updated version of the USDA-USFS Forest Inventory and Analysis (FIA) vegetation speciation based data from 2001 to 2014 from the FIA version 5.1. Canopy coverage is based on the Landsat satellite National Land Cover Database (NLCD) product from 2011. 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 NLCD canopy coverage. The 2011 NLCD provides land cover information with a native data grid spacing of 30 meters. For land areas outside the conterminous United States, 500 meter grid spacing land cover data from the Moderate Resolution Imaging Spectroradiometer (MODIS) is used.

Other improvements to the BELDv4.1 included the following:

- Used 30 meter NASA's Shuttle Radar Topography Mission (SRTM) elevation data (http://www2.jpl.nasa.gov/srtm/) which will more accurately define the elevation ranges of the vegetation species.
- Used the 2011 30 meter USDA Cropland Data Layer (CDL) data (http://www.nass.usda.gov/research/Cropland/Release/) to the BELD 4 agricultural categories.

To provide a sense of the scope and spatial distribution of the emissions, plots of annual BEIS outputs for isoprene and NO for 2011 are shown in Figure 2-3 and Figure 2-4, respectively.

2.9 SMOKE-ready non-anthropogenic inventories for chlorine

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.

Figure 2-3. Annual NO emissions output from BEIS 3.61 for 2011

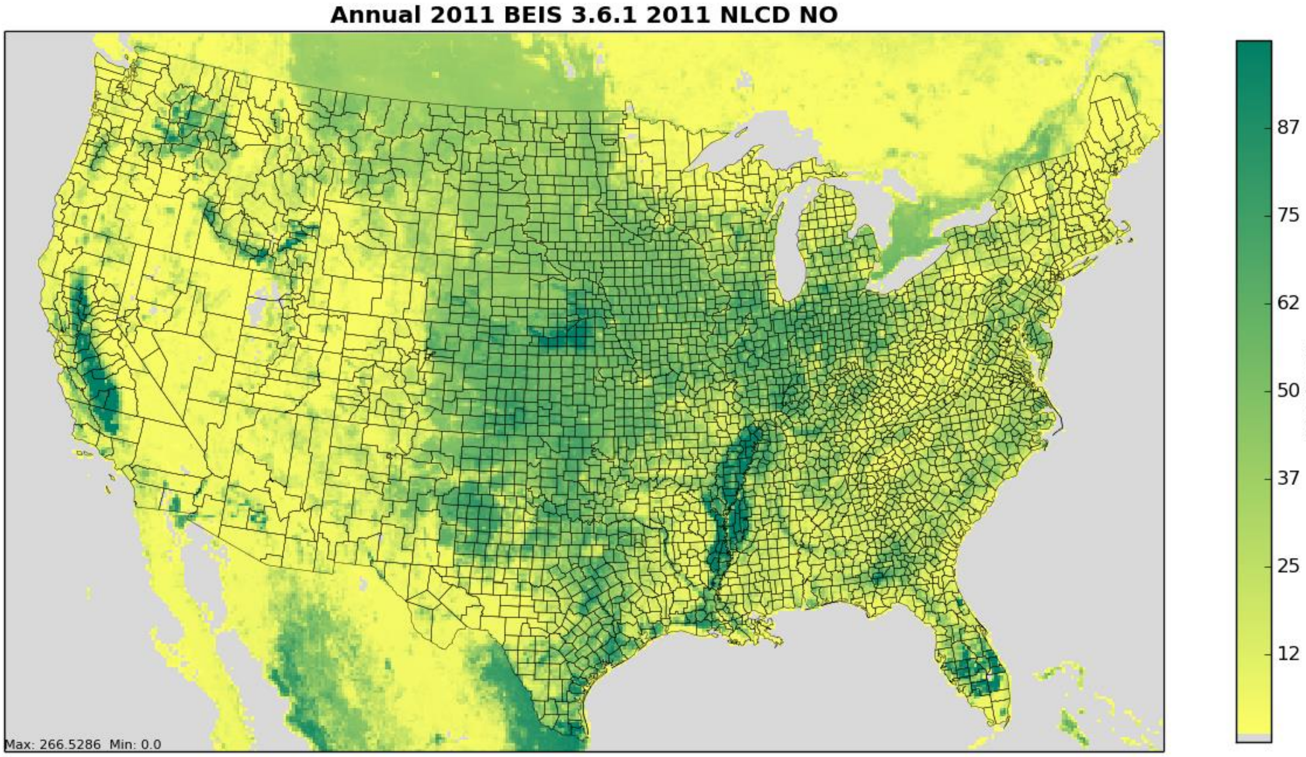
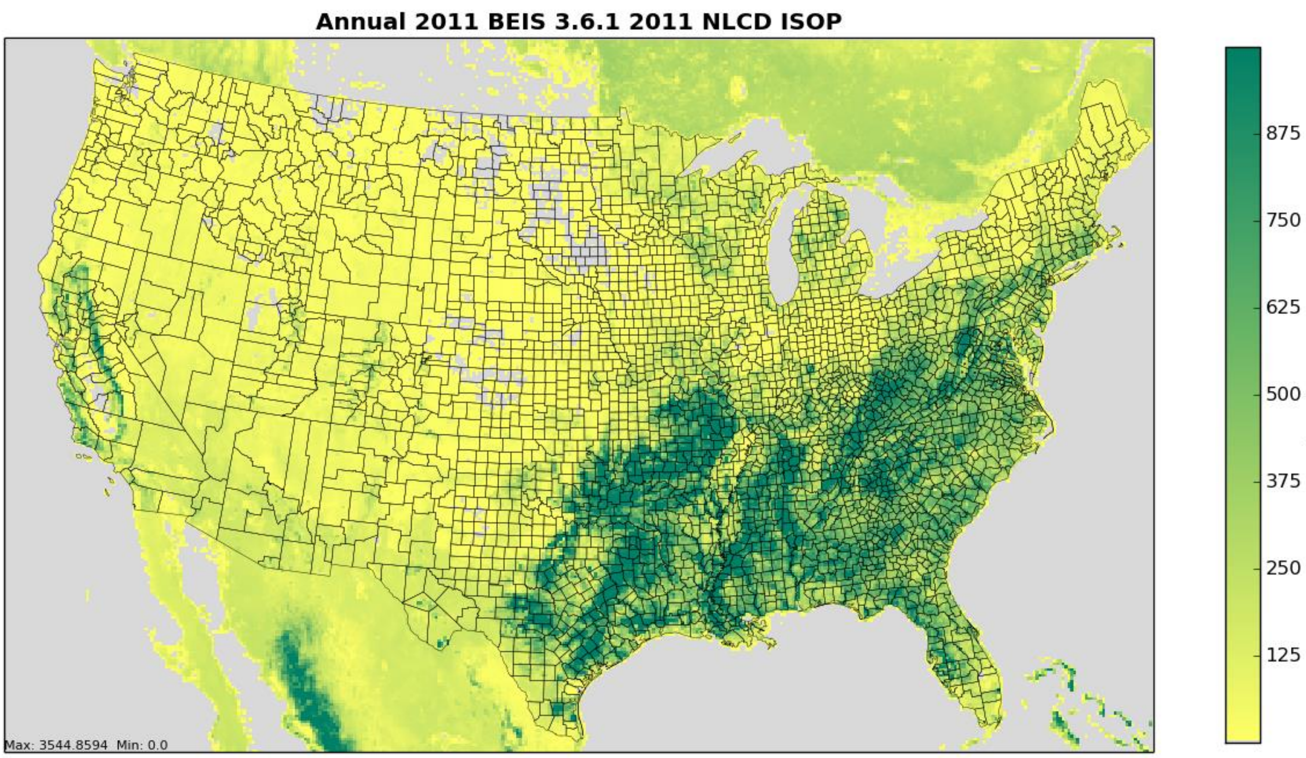


Figure 2-4. Annual isoprene emissions output from BEIS 3.61 for 2011



3 Emissions Modeling Summary

In Section 3, the descriptions of data are limited to updates to the ancillary data SMOKE uses to perform the emissions modeling steps. Note that all SMOKE inputs for this updated 2011v6.3 platform are available from the Air Emissions Modeling ftp site. While an overview of emissions modeling is given below, the details of the emissions modeling for the platform can be found in the original 2011v6.3 TSD (EPA, 2016a).

Both the CMAQ and CAMx 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 resolution required by the air quality model. Emissions modeling includes temporal allocation, spatial allocation, and pollutant speciation. In some cases, emissions modeling also includes the vertical allocation 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 data are not provided for all vertical layers being modeled.

SMOKE version 3.7 was used to pre-process the raw emissions inventories into emissions inputs for each modeling sector in a format compatible with CMAQ. For projects that used CAMx, the CMAQ-formatted emissions were converted into the required CAMx formats using CAMx convertor programs. For sectors that have plume rise, the in-line emissions capability of the air quality models was used, which allows the creation of source-based and two-dimensional gridded emissions files that are much smaller than full three-dimensional gridded emissions files. For quality assurance of the emissions modeling steps, emissions totals for all species across 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.

The changes made to the ancillary emissions modeling files in the 2011en platform update are the following and are described in more detail in the subsections that follow:

- updates to speciation cross references for Canadian emissions;
- updates to temporal profiles for nonroad mobile source emissions;
- updates to temporal profiles used for U.S. EGUs;
- updates to temporal profiles for Canadian emissions;
- updates to plume rise treatment for U.S. C3 CMV sources;
- updates to spatial surrogates used in Canada, Mexico, and for U.S. CMV sources.

The changes made to the ancillary emissions modeling files in the 2011el platform update were the following and are described in more detail in the subsections that follow:

- updates related to the processing of MOVES-Mexico inventory data, including speciation, temporal, and gridding cross-references, speciation profiles, and inventory table;
- updates to the speciation cross reference to support fires in Canada and Mexico;
- development of speciation cross reference and GSPRO_COMBO files for 2023;

- updates to monthly temporal profiles and the temporal cross reference for processing 2023 California nonroad emissions;
- development of MRCLIST files for 2023 onroad emission factors;
- development of CFPRO files for 2011 and 2023 onroad California and Texas adjustments; and
- updates to NHAPEXCLUDE files for some 2023 sectors.

3.1 Emissions Modeling Overview

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 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. 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. The air quality model computes the plume rise using the stack data and the hourly air quality model inputs found in the SMOKE output files for each model-ready emissions sector. The height of the plume rise determines the model layer into which the emissions are placed. The othpt sector has only “in-line” emissions, meaning that all of the emissions are treated as elevated sources and there are no emissions for those sectors in the two-dimensional, layer-1 files created by SMOKE. Day-specific point fires are treated separately. For CMAQ modeling, fire plume rise is done within CMAQ itself, but for CAMx, the plume rise is done by running SMOKE to create a three-dimensional output file and then those emissions are postprocessed into a point source format that CAMx can read. In either case, after plume rise is applied, there will be emissions in every layer from the ground up to the top of the plume.

Table 3-1. Key emissions modeling steps by sector for 2011en

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
afdust	Surrogates	Yes	annual	
ag	Surrogates	Yes	annual	
agfire	Surrogates	Yes	monthly	
beis	Pre-gridded land use	in BEIS3.61	computed hourly	
rail	Surrogates	Yes	annual	
cmv_c1c2	Surrogates	Yes	annual	

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
nonpt	Surrogates & area-to-point	Yes	annual	
nonroad	Surrogates & area-to-point	Yes	monthly	
np_oilgas	Surrogates	Yes	annual	
onroad	Surrogates	Yes	monthly activity, computed hourly	
othafdust	Surrogates	Yes	annual	
othar	Surrogates	Yes	annual & monthly	
othon	Surrogates	Yes	monthly	
othpt	Point	Yes	annual & monthly	in-line
cmv_c3	Point + surrogates	Yes	Annual	in-line
ptegu	Point	Yes	daily & hourly	in-line
ptfire	Point	Yes	daily	in-line
ptfire_mxca	Point	Yes	daily	in-line
ptnonipm	Point	Yes	annual	in-line
pt_oilgas	Point	Yes	annual	in-line
rwc	Surrogates	Yes	annual	

SMOKE has the option of grouping sources so that they are treated as a single stack when computing plume rise. For the 2011 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 three-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.

To prepare fires for CAMx using a plume rise algorithm that is consistent with the algorithms in SMOKE and CMAQ, the following steps are performed:

1) The ptfire inventories are run through SMOKE programs to read the inventories, speciate, temporalize, and grid the emissions.
2) The SMOKE program laypoint is used to estimate the plume height and layer fractions for each fire (see https://www.cmascenter.org/smoke/documentation/3.7/html/ch06s06.html#sect_programs_laypoint_plume_rise_fires).
3) The emissions are gridded and layered, and then written as three-dimensional netCDF CMAQ ready files.
4) Species in the CMAQ-formatted file are converted to CAMx species using the *spcmap* program.
5) The netCDF **ptfire** files are converted to a CAMx "PTSOURCE" type file where each grid cell centroid represents one stack using the *cmaq2uam* program. Note that each virtual stack has default stack parameters of 1 m height, 1 m diameter, 273 K temperature, and 1 m/s

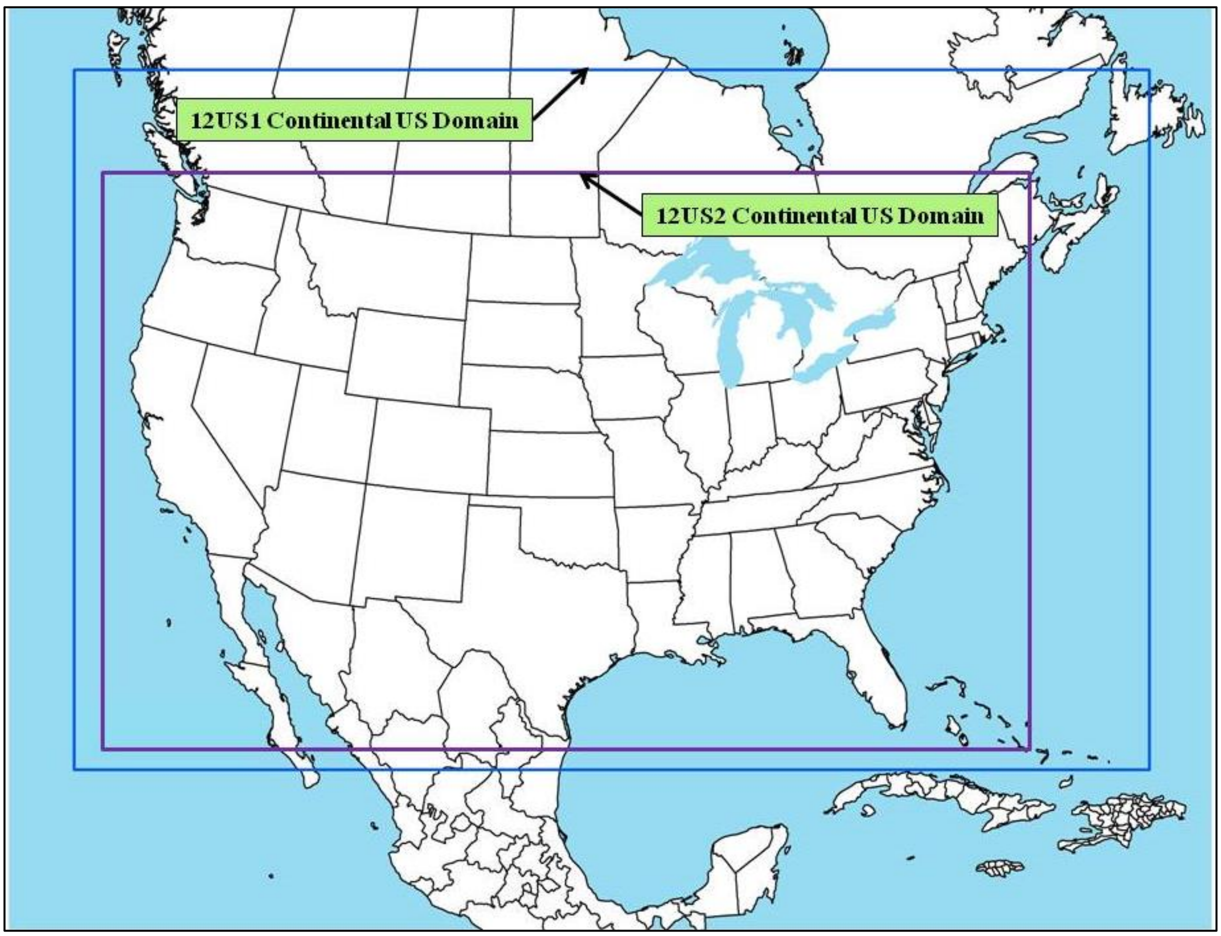
velocity. Also, an individual virtual stack point (grid cell centroid) will have all of the emissions for the grid cell divided up into layers with an effective plume height at each layer. Only the layers that contain emissions are kept for each virtual stack.

6) The program *pthtq* is run to add an effective plume height based on the cell center height from the METCRO3D (ZH).

7) The resulting PTSOURCE files have emissions as a stack at (x, y) that to up to layer z that is derived from the CMAQ 3D file, and are merged with the PTSOURCE sector files from other sectors into a single PTSOURCE file with stacks for all point sources. This file, along with the 2D emissions file, is input into the CAMx model.

SMOKE was run for the smaller 12-km CONtinental United States "CONUS" modeling domain (12US2) shown in Figure 3-1 and boundary conditions were obtained from a 2011 run of GEOS-Chem.

Figure 3-1. Air quality modeling domains



Both 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 two 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 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

Section 3.4 provides the details on the spatial surrogates and area-to-point data used to accomplish spatial allocation with SMOKE.

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 2011 platform is the CB6 mechanism (Yarwood, 2010). The 2011v6.2 platform was the first EPA modeling platform to use CB6; previous platforms used CB05 and earlier versions of the carbon bond mechanism. The key difference in CB6 from CB05 from an emissions modeling perspective is that it has additional lumped and explicit model species. The specific version of CAMx used in applications of this platform include secondary organic aerosol (SOA) and nitrous acid (HONO) enhancements. In addition, this platform generates the $PM_{2.5}$ model species associated with the CMAQ Aerosol Module version 6 (AE6), though many are not used by CAMx. Table 3-3 of the 2011v6.3 platform TSD lists the model species produced by SMOKE in the 2011v6.2 platform Table 3-4 of the 2011v6.3 platform TSD (EPA, 2016a) provides the cmaq2camx mapping file used to convert the SMOKE generated model species to the appropriate inputs for CAMx.

The total organic gas (TOG) and $PM_{2.5}$ speciation factors that are the basis of the chemical speciation approach were developed from the SPECIATE 4.4 database https://www.epa.gov/air-emissions-modeling/speciate-version-45-through-40), which is the EPA's repository of TOG and PM speciation profiles of air pollution sources. However, a few of the profiles used in the v6.3 platform such as composite profiles for chemical manufacturing and pulp and paper sources will be published in later versions of the SPECIATE database after the release of this documentation. 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, 2006a). 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 $PM_{2.5}$.

Some special species are available in the emissions output from SMOKE: VOC_INV and NH3_FERT. The VOC_INV specie is carried through the modeling of each of the sectors so that emission summaries can be prepared for VOC without having to sum back up the individual VOC species which have different molecular weights. The VOC_INV is the total the amount of VOC in the input inventories and has units of g/s. The NH3_FERT is a specie that CMAQ uses for bidirectional ammonia modeling. It is set to the amount of ammonia from fertilizer sources. If the bidirectional option is turned off, the specie is ignored. It is also ignored for CAMx modeling.

Only minor changes were made to the speciation cross reference in 2011el update to the 2011v6.3 platform and there were no changes to U.S. speciation made for 2011en. Speciation for the updated 2011 emissions is the same as in the 2011 emissions from the 2011v6.3 platform, with the new ptfire_mxca sector emissions receiving the same speciation as the ptfire sector. Speciation for the 2023 emissions is the same as in the 2017 emissions from the 2011v6.3 platform, except for the VOC speciation COMBO profiles for bulk plant terminal-to-pump (BTP) emissions. COMBO profiles for 2023 were interpolated based on 2017 and 2025 COMBO profiles from the 2011v6.2 and 2011v6.3 emissions platforms.

The speciation cross reference and inventory table for the othon sector were configured so that VOC, $PM_{2.5}$ and NO_X are speciated in Canada only. In Mexico, pre-speciated VOC, $PM_{2.5}$, and NOx emissions from MOVES-Mexico are used. Some updates to speciation cross references in Canada were needed to accommodate new SCCs in the Canadian 2013 inventory.

Speciation profiles and cross-references for the 2011v6.3 platform are available in the SMOKE input files for the 2011v6.3 platform. Totals of each model species by state and sector can be found in the state-sector totals workbooks for the respective cases. In addition, the county-monthly reports for each case include EC and OC, and the 2011ek_county_SCC7_sector_CAP_PM.xlsx workbook contains speciated PM by county and the first seven digits of the SCC code.

Table 3-3. Emission model species produced for CB6 for CAM_X*

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
VOC	ACET	Acetone
	ALD2	Acetaldehyde
	ALDX	Propionaldehyde and higher aldehydes
	BENZ	Benzene
	CH4	Methane[6]
	ETH	Ethene
	ETHA	Ethane
	ETHY	Ethyne
	ETOH	Ethanol
	FORM	Formaldehyde
	KET	Ketone Groups

[6] Technically, CH_4 is not a VOC but part of TOG. Although emissions of CH_4 are derived, the AQ models do not use these emissions because the anthropogenic emissions are dwarfed by the CH_4 already in the atmosphere.

Inventory Pollutant	Model Species	Model species description
	IOLE	Internal olefin carbon bond (R-C=C-R)
	ISOP	Isoprene
	MEOH	Methanol
	OLE	Terminal olefin carbon bond (R-C=C)
	PAR	Paraffin carbon bond
	PRPA	Propane
	TOL	Toluene and other monoalkyl aromatics
	XYL	Xylene and other polyalkyl aromatics
VOC species from the biogenics model that do not map to model species above	SESQ	Sesquiterpenes
	TERP	Terpenes
PM_{10}	PMC	Coarse PM > 2.5 microns and ≤ 10 microns
$PM_{2.5}$	PAL	Aluminum
	PCA	Calcium
	PCL	Chloride
	PEC	Particulate elemental carbon ≤ 2.5 microns
	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
	PNO3	Particulate nitrate ≤ 2.5 microns
	PNH4	Ammonium
	POC	Particulate organic carbon (carbon only) ≤ 2.5 microns
	PSI	Silica
	PSO4	Particulate Sulfate ≤ 2.5 microns
	PTI	Titanium
Sea-salt species (non – anthropogenic) [7]	PCL	Particulate chloride
	PNA	Particulate sodium

*Notes:
1. CL2 is not used in CAM_X and is provided above because of its use in CMAQ
2. CAM_X particulate sodium is NA (in CMAQ it is PNA)
3. CAM_X uses different names for species that are both in CB6 and SOA for the following: TOLA=TOL, XYLA=XYL, ISP=ISOP, TRP=TERP. They are duplicate species in CAM_X that are used in the SOA chemistry. CMAQ uses the same names in CB05 and SOA for these species.
4. CAM_X uses a different name for sesquiterpenes: CMAQ SESQ = CAM_X SQT
5. CAM_X particulate species have different names for organic carbon, coarse particulate matter and other particulate mass: CAM_X uses POA, CPRM, FCRS, and FPRM, respectively.

[7] These emissions are created outside of SMOKE

Table 3-4. Cmaq2camx mapping file

CMAQ Species	CMAQ to CAMx Factor	CAMx Species	Units	CMAQ Species	CMAQ to CAMx Factor	CAMx Species	Units
SO2	1	SO2	moles/hr	UNR	1	NR	moles/hr
SULF	1	SULF	moles/hr	NR	1	NR	moles/hr
NH3	1	NH3	moles/hr	TOL	1	TOLA	moles/hr
CO	1	CO	moles/hr	XYL	1	XYLA	moles/hr
NO	1	NO	moles/hr	PSO4	1	PSO4	g/hr
NO2	1	NO2	moles/hr	PH2O	1	PH2O	g/hr
HONO	1	HONO	moles/hr	PNH4	1	PNH4	g/hr
CL2	1	CL2	moles/hr	PNO3	1	PNO3	g/hr
HCL	1	HCL	moles/hr	PEC	1	PEC	g/hr
CH4	1	CH4	moles/hr	POC	1	POC	g/hr
PAR	1	PAR	moles/hr	PMOTHR	1	PMOTHR	g/hr
ETHA	1	ETHA	moles/hr	PMC	1	CPRM	g/hr
MEOH	1	MEOH	moles/hr	ISOP	1	ISP	moles/s
ETOH	1	ETOH	moles/hr	TERP	1	TRP	moles/s
ETH	1	ETH	moles/hr	SESQ	1	SQT	moles/s
OLE	1	OLE	moles/hr	PCL	1	PCL	g/hr
IOLE	1	IOLE	moles/hr	PNCOM	1	PNCOM	g/hr
ISOP	1	ISOP	moles/hr	PAL	1	PAL	g/hr
TERP	1	TERP	moles/hr	PCA	1	PCA	g/hr
FORM	1	FORM	moles/hr	PFE	1	PFE	g/hr
ALD2	1	ALD2	moles/hr	PMG	1	PMG	g/hr
ALDX	1	ALDX	moles/hr	PK	1	PK	g/hr
TOL	1	TOL	moles/hr	PMN	1	PMN	g/hr
XYL	1	XYL	moles/hr	PSI	1	PSI	g/hr
PRPA	1	PRPA	moles/hr	PTI	1	PTI	g/hr
ETHY	1	ETHY	moles/hr	PNA	1	NA	g/hr
BENZ	1	BENZ	moles/hr	POC	1	POA	g/hr
ACET	1	ACET	moles/hr	PNCOM	1	POA	g/hr
KET	1	KET	moles/hr				

3.2.1 VOC speciation

The concept of VOC speciation is to use emission source-related speciation profiles to convert VOC to TOG, to speciate TOG into individual chemical compounds, and to use a chemical mechanism mapping file to aggregate the chemical compounds to the chemical mechanism model species. The chemical mechanism mapping file is typically developed by the developer of the chemical mechanism.

SMOKE uses profiles that convert inventory species and TOG directly to the model species. The SMOKE-ready profiles are generated from the Speciation Tool which uses the "raw" (TOG to chemical compounds) SPECIATE profiles and the chemical mechanism mapping file.

For the 2011v6.3 platform, an updated CB6 chemical mapping file based on the August 2014 mechanism table for CB05 from Bill Carter was used for all sectors, including onroad mobile sources.

This CB6 mapping file included some corrections to the onroad CB05 profiles used in the 2011v6.2 platform. Similarly to previous platforms, HAP VOC inventory species were used in the VOC speciation process for some sectors as described below.

3.2.1.1 The combination of HAP BAFM (benzene, acetaldehyde, formaldehyde and methanol) and VOC for VOC speciation

The VOC speciation includes HAP emissions from the 2011NEIv2 in the speciation process. Instead of speciating VOC to generate all of the species listed in Table 3-3, emissions of four specific HAPs: benzene, acetaldehyde, formaldehyde and methanol (collectively known as "BAFM") 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 BAFM HAPs were chosen for integration in previous platforms because, with the exception of BENZENE[8], they are the only explicit VOC HAPs in the base version of the CMAQ 5.0.2 (CAPs only with chlorine chemistry) model. These remain appropriate for the 2011v6.3 platform since they are all explicit in CAMx. 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."

For specific sources, especially within the nonpt sector, the integration included ethanol. To differentiate when a source was integrating BAFM versus EBAFM (ethanol in addition to BAFM), the speciation profiles that do not include ethanol are referred to as an "E-profile" and should be used when ethanol comes from the inventory. For example, the E10 headspace gasoline evaporative speciation profile 8763 should be used when ethanol is speciated from VOC, but 8763E should be used when ethanol is obtained directly from the inventory.

The integration of HAP VOC with VOC is a feature available in SMOKE for all inventory formats other than PTDAY (the format used for the ptfire sector). SMOKE allows the user to specify both the particular HAPs to integrate via the INVTABLE and the particular sources to integrate via the NHAPEXCLUDE file (which actually provides the sources to be *excluded* from integration[9]). For the "integrated" sources, SMOKE subtracts the "integrated" HAPs from the VOC (at the source level) to compute emissions for the new pollutant "NONHAPVOC." The user provides NONHAPVOC-to-NONHAPTOG factors and NONHAPTOG speciation profiles[10]. 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

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[8] BENZENE was chosen to keep its emissions consistent between the multi-pollutant and base versions of CMAQ.

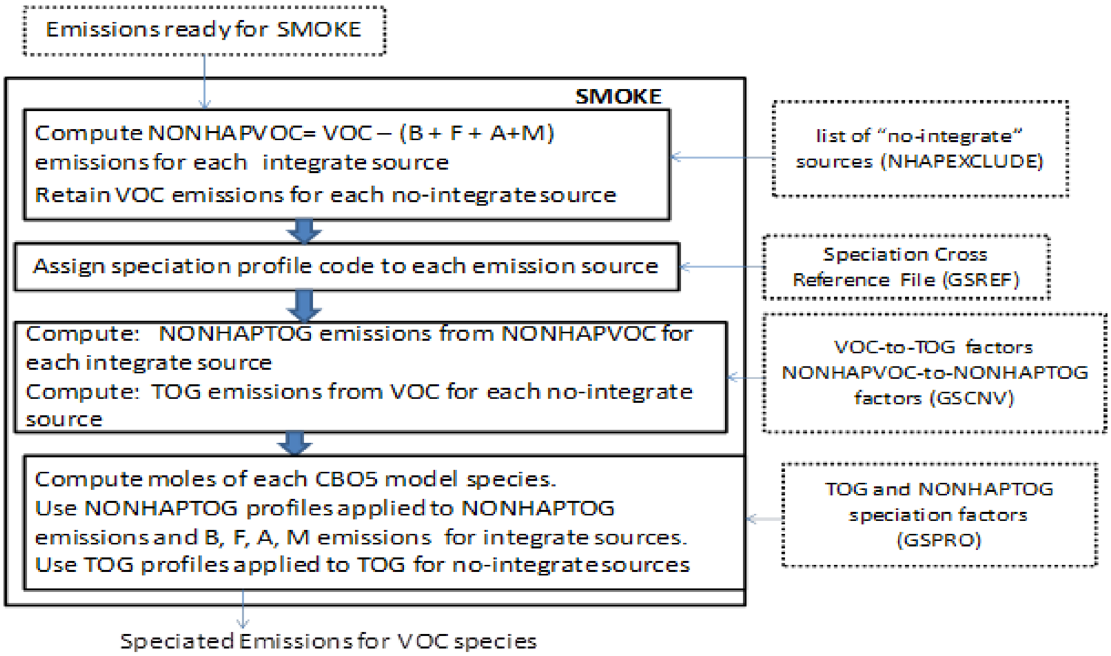
[9] In SMOKE version 3.7, the options to specify sources for integration are expanded so that a user can specify the particular sources to include or exclude from integration, and there are settings to include or exclude all sources within a sector. In addition, the error checking is significantly stricter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

[10] 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 BAFM.

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 and developed "integration criteria" for some of them (see Section 3.2.1.3 for details).

The process of partial integration for BAFM is illustrated in Figure 3-2 that the BAFM records in the input inventories do not need to be removed from any sources in a partially integrated sector because SMOKE does this automatically using the INVTABLE configuration. For EBAFM integration, this process is identical to that shown in the figure except for the addition of ethanol (E) to the list of subtracted HAP pollutants. For full integration, the process would be very similar except that the NHAPEXCLUDE file would not be used and all sources in the sector would be integrated.

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



In SMOKE, the INVTABLE allows the user to specify both the particular HAPs to integrate. Two different types of INVTABLE files are included for use with different sectors of the platform. For sectors that had no integration across the entire sector (see Table 3-5), the EPA created a "no HAP use" INVTABLE in which the "KEEP" flag is set to "N" for BAFM pollutants. Thus, any BAFM 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 BAFM 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 four HAP pollutants. This type of INVTABLE is further differentiated into a version for those sectors that integrate BAFM and another for those that integrate EBAFM.

Table 3-5. Integration approach for BAFM and EBAFM for each platform sector

Platform Sector	Approach for Integrating NEI emissions of Benzene (B), Acetaldehyde (A), Formaldehyde (F), Methanol (M), and Ethanol (E)
ptegu	No integration
ptnonipm	No integration
ptfire	No integration
othafdust	No integration
othar	No integration
othon	No integration
ag	N/A – sector contains no VOC
afdust	N/A – sector contains no VOC
biog	N/A – sector contains no inventory pollutant "VOC"; but rather specific VOC species
agfire	Partial integration (BAFM)
cmv	Partial integration (BAFM)
rail	Partial integration (BAFM)
nonpt	Partial integration (BAFM and EBAFM)
nonroad	Partial integration (BAFM)
np_oilgas	Partial integration (BAFM)
pt_oilgas	Partial integration (BAFM)
rwc	Partial integration (BAFM)
othpt	Partial integration (BAFM)
onroad	Full integration (internal to MOVES)[1]
[1]For the integration that is internal to MOVES, an extended list of HAPs are integrated, not just BAFM. See 3.2.1.3	

More details on the integration of specific sectors and additional details of the speciation are provided in Section 3.2.1.3.

3.2.1.2 County specific profile combinations (GSPRO_COMBO)

SMOKE can compute speciation profiles from mixtures of other profiles in user-specified proportions. The combinations are specified in the GSPRO_COMBO ancillary file by pollutant (including pollutant mode, e.g., EXH__VOC), state and county (i.e., state/county FIPS code) and time period (i.e., month). This feature was used to speciate nonroad mobile and gasoline-related stationary sources that use fuels with varying ethanol content. In these cases, the speciation profiles require different combinations of gasoline profiles, e.g. E0 and E10 profiles. Since the ethanol content varies spatially (e.g., by state or county), temporally (e.g., by month), and by modeling year (future years have more ethanol), the GSPRO_COMBO feature allows combinations to be specified at various levels for different years. SMOKE computes the resultant profile using the fraction of each specific profile assigned by county, month and emission mode.

The GSREF file indicates that a specific source uses a combination file with the profile code "COMBO." Because the GSPRO_COMBO file does not differentiate by SCC and there are various levels of integration across sectors, sector-specific GSPRO_COMBO files are used. Different profile combinations are specified by the mode (e.g., exhaust, evaporative) and by changing the pollutant name (e.g., EXH__NONHAPTOG, EVP__NONHAPTOG). For the nonpt sector, a combination of BAFM and EBAFM integration is used. Due to the lack of SCC-specificity in the GSPRO_COMBO, the only way to differentiate the sources that should use BAFM integrated profiles versus E-profiles is by changing the pollutant name. For example, the EPA changed the pollutant name for the PFC future year inventory so the integration would use EVP__NONHAPVOC to correctly select the E-profile combinations, while other sources used NONHAPVOC to select the typical BAFM profiles.

3.2.1.3 Additional sector specific details

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 BAFM (BAFM HAPs subtracted from VOC) or EBAFM (ethanol and BAFM HAPs subtracted from VOC). Table 3-5 above summarizes the integration method for each platform sector.

For the cmv and rail sectors, the EPA integrated BAFM for most sources. There were a few sources that had zero BAFM and, therefore, they were not integrated. The CARB inventories (see Section 2.4.1) did not include HAPs and, therefore, all non-NEI source emissions in the cmv and rail sectors were not integrated. For California, the CARB inventory TOG was converted to VOC by dividing the inventory TOG by the available VOC-to-TOG speciation factor.

For the othpt sector, the C3 marine sources (see Section 2.4.2) are integrated. HAPs in this sector are derived identically to the U.S. C3 in the cmv sector. The rest of the sources in othpt are not integrated, thus the sector is partially integrated.

For the onroad sector, there are series of unique speciation issues. First, SMOKE-MOVES (see Section 2.3.1) 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 EF tables that include inventory pollutants (e.g., TOG) and model-ready species (e.g., PAR, OLE, etc)[11]. SMOKE essentially calculates the model-ready species by using the appropriate emission factor without further speciation[12]. Third, MOVES' internal speciation uses full integration of an extended list of HAPs beyond EBAFM (called "M-profiles"). The M-profiles integration is very similar to BAFM integration explained above except that the integration calculation (see Figure 3-2) is performed on emissions factors instead of on emissions. The list of integrated HAPs 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 and Texas EPA applied adjustment factors to SMOKE-MOVES to produce California and Texas adjusted model-ready files (see Section 2.3.1 for details). By applying the ratios through SMOKE-MOVES, the CARB and TCEQ inventories are essentially speciated to match EPA estimated speciation.

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[11] 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.

[12] 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/.

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, CNG or LPG sources (SCCs beginning with 2268 or 2267) are not integrated because NMIM computed only VOC and not any HAPs for these SCCs. All other nonroad sources were integrated except in California. For California, the CARB inventory TOG was converted to VOC by dividing the inventory TOG by the available VOC-to-TOG speciation factor. SMOKE later applies the same VOC-to-TOG factor prior to computing speciated emissions. The CARB-based nonroad data includes exhaust and evaporative mode-specific data for VOC, but does not contain refueling. The CARB inventory does not include HAP estimates for all sources. Therefore, the sources which have VOC but not BAFM, or for which BAFM is greater than VOC, are not integrated and the remaining sources are integrated. The future year CARB inventories did not have BAFM so all sources for California were not integrated. The gasoline exhaust profiles were updated to 8750a and 8751a (this is true nation-wide).

Aircraft emissions use the profile 5565. In previous versions of the platform, a significant amount of VOC emissions associated with the pulp and paper and the chemical manufacturing industries did not have specific profiles assigned to them (i.e., they had the default VOC profile 0000). To address this, the EPA and Ramboll developed industry-wide average profiles to improve the speciation of these significant sources of VOC, since a large portion of the SCCs related to these industries used the default profile 00000. The two new composite profiles are "Composite Profile – Chemical Manufacturing (95325)" and "Composite Profile – Pulp and Paper Mills" (95326)[13].

For most sources in the rwc sector, the VOC emissions were greater than or equal to BAFM, and BAFM was not zero, so those sources were integrated, although a few specific sources that did not meet these criteria could not be integrated. For the oil and gas sources in the np_oilgas and pt_oilgas sectors, the basins studied in WRAP Phase III have basin-specific VOC speciation that takes into account the

[13] These profiles are expected to be included in SPECIATE 4.5.

distinct composition of gas. ENVIRON developed these basin-specific profiles using gas composition analysis data obtained from operators through surveys. ENVIRON separated out emissions and speciation from conventional/tight sands/shale gas from coal-bed methane (CBM) gas sources. Table 3-7 lists the basin- and gas composition-specific profiles used for the sources in the WRAP Phase III basins. For oil and gas sources outside of the WRAP Phase III basins, the profiles did not vary by region or basin (see Table 3-8). Table 3-9 lists the WRAP Phase III counties.

Table 3-7. VOC profiles for WRAP Phase III basins

Profile Code	Description
DJFLA	D-J Basin Flashing Gas Composition for Condensate
DJVNT	D-J Basin Produced Gas Composition
PNC01	Piceance Basin Gas Composition at Conventional Wells
PNC02	Piceance Basin Gas Composition at Oil Wells
PNC03	Piceance Basin Flashing Gas Composition for Condensate
PRBCO	Powder River Basin Produced Gas Composition for Conventional Wells
PRM01	Permian Basin Produced Gas Composition
SSJCO	South San Juan Basin Produced Gas Composition for Conventional Wells
SWFLA	SW Wyoming Basin Flash Gas Composition
SWVNT	SW Wyoming Basin Vented Gas Composition
UNT02	Uinta Basin Gas Composition at Conventional Wells
UNT03	Uinta Basin Flashing Gas Composition for Oil
UNT04	Uinta Basin Flashing Gas Composition for Condensate
WRBCO	Wind River Basin Produced Gas Composition for Conventional Wells

Table 3-8. National VOC profiles for oil and gas

Profile	Description
0000	Over All Average
0001	External Combustion Boiler - Residual Oil
0002	External Combustion Boiler - Distillate Oil
0003	External Combustion Boiler - Natural Gas
0004	External Combustion Boiler - Refinery Gas
0007	Natural Gas Turbine
0008	Reciprocating Diesel Engine
0051	Flares - Natural Gas
0296	Fixed Roof Tank - Crude Oil Production
1001	Internal Combustion Engine - Natural Gas
1010	Oil and Gas Production - Fugitives - Unclassified
1011	Oil and Gas Production - Fugitives - Valves and Fittings - Liquid Service
1012	Oil and Gas Production - Fugitives - Valves and Fittings - Gas Service
1207	Well Heads (Water Flood) Composite
2487	Composite of 7 Emission Profiles from Crude Oil Storage Tanks - 1993
2489	Composite of 15 Fugitive Emission Profiles from Petroleum Storage Facilities - 1993
8489	Natural Gas Production
8950	Natural Gas Transmission

Table 3-9. Counties included in the WRAP Dataset

FIPS	State	County
08001	CO	Adams
08005	CO	Arapahoe
08007	CO	Archuleta
08013	CO	Boulder
08014	CO	Broomfield
08029	CO	Delta
08031	CO	Denver
08039	CO	Elbert
08043	CO	Fremont
08045	CO	Garfield
08051	CO	Gunnison
08059	CO	Jefferson
08063	CO	Kit Carson
08067	CO	La Plata
08069	CO	Larimer
08073	CO	Lincoln
08075	CO	Logan
08077	CO	Mesa
08081	CO	Moffat
08087	CO	Morgan
08095	CO	Phillips
08097	CO	Pitkin
08103	CO	Rio Blanco
08107	CO	Routt
08115	CO	Sedgwick
08121	CO	Washington
08123	CO	Weld
08125	CO	Yuma
30003	MT	Big Horn
30075	MT	Powder River
35005	NM	Chaves
35015	NM	Eddy
35015	NM	Lea
35031	NM	Mc Kinley
35039	NM	Rio Arriba
35041	NM	Roosevelt
35043	NM	Sandoval
35045	NM	San Juan
48003	TX	Andrews
48033	TX	Borden
48079	TX	Cochran
48081	TX	Coke
48103	TX	Crane
48105	TX	Crockett
48107	TX	Crosby
48109	TX	Culberson
48115	TX	Dawson
48125	TX	Dickens
48135	TX	Ector
48141	TX	El Paso
48151	TX	Fisher
48165	TX	Gaines
48169	TX	Garza
48173	TX	Glasscock
48219	TX	Hockley
48227	TX	Howard
48229	TX	Hudspeth
48235	TX	Irion
48263	TX	Kent
48269	TX	King
48301	TX	Loving
48303	TX	Lubbock
48305	TX	Lynn
48317	TX	Martin
48329	TX	Midland
48335	TX	Mitchell
48353	TX	Nolan
48371	TX	Pecos
48383	TX	Reagan
48389	TX	Reeves
48413	TX	Schleicher
48415	TX	Scurry
48431	TX	Sterling
48435	TX	Sutton
48445	TX	Terry
48451	TX	Tom Green
48461	TX	Upton
48475	TX	Ward
48495	TX	Winkler
48501	TX	Yoakum
49007	UT	Carbon
49009	UT	Daggett
49013	UT	Duchesne
49015	UT	Emery
49019	UT	Grand
49043	UT	Summit
49047	UT	Uintah
56001	WY	Albany
56005	WY	Campbell
56007	WY	Carbon
56009	WY	Converse
56011	WY	Crook
56013	WY	Fremont
56019	WY	Johnson
56023	WY	Lincoln
56025	WY	Natrona
56027	WY	Niobrara
56033	WY	Sheridan
56035	WY	Sublette
56037	WY	Sweetwater
56041	WY	Uinta
56045	WY	Weston

Everywhere in the WRAP region (Table 3-9), WRAP speciation was applied instead of applying BAFM integration. VOC-to-TOG factors for WRAP speciation profiles were also updated for the 2011v6.3 platform. For the biog sector, the speciation profiles used by BEIS are not included in SPECIATE. The 2011 platform uses BEIS3.61, which includes a new species (SESQ) that was mapped to the model species SESQT. The profile code associated with BEIS3.61 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.

For the nonpt sector, where VOC emissions were greater than or equal to BAFM and BAFM was not zero, the sources were integrated. For portable fuel containers (PFCs) and fuel distribution operations associated with the bulk-plant-to-pump (BTP) distribution, ethanol may be mixed into the fuels; therefore, county- and month-specific COMBO speciation was used (via the GSPRO_COMBO file). 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. For the future year, PFC and the cellulosic sources were integrated EBAFM (i.e., used E-profiles) because ethanol was present in those inventories.

3.2.1.4 Future year speciation

The VOC speciation approach used for the future year case is customized to account for the impact of fuel changes. These changes affect the onroad, nonroad, and parts of the nonpt and ptnonipm sectors.

Speciation profiles for VOC in the nonroad sector account for the changes in ethanol content of fuels across years. A description of the actual fuel formulations for 2011 can be found in the 2011NEIv2 TSD, and for 2023, see Section 4.3. For 2011, the EPA used "COMBO" profiles to model combinations of profiles for E0 and E10 fuel use. For 2023, the EPA assumed E10 fuel use for all nonroad gasoline processes.

The speciation changes from fuels in the nonpt sector are for PFCs and fuel distribution operations associated with the BTP distribution. 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. RBT fuel distribution and BPS speciation does not change across the modeling cases because this is considered upstream from the introduction of ethanol into the fuel. For PFCs, ethanol was present in the future inventories and, therefore, EBAFM profiles were used to integrate ethanol in the future year speciation.

Table 3-10 summarizes the different profiles utilized for the fuel-related sources in each of the sectors for 2011 and the future year cases. This table indicates when "E-profiles" were used instead of BAFM integrated profiles. The term "COMBO" indicates that a combination of the profiles listed was used to speciate that subcategory using the GSPRO_COMBO file.

Table 3-10. Select VOC profiles 2011 vs 2023

Sector	Sub-category	2011		2023	
nonroad	gasoline exhaust	COMBO		8751a	Pre-Tier 2 E10 exhaust
		8750a	Pre-Tier 2 E0 exhaust		
		8751a	Pre-Tier 2 E10 exhaust		
nonroad	gasoline evap-orative	COMBO		8754	E10 evap
		8753	E0 evap		
		8754	E10 evap		

Sector	Sub-category	2011		2023	
nonroad	gasoline refueling	COMBO 8869 8870	 E0 Headspace E10 Headspace	8870	E10 Headspace
nonroad	diesel exhaust	8774	Pre-2007 MY HDD exhaust	8774	Pre-2007 MY HDD exhaust
nonroad	diesel evap-orative	4547	Diesel Headspace	4547	Diesel Headspace
nonroad	diesel refueling	4547	Diesel Headspace	4547	Diesel Headspace
nonpt/ ptnonipm	PFC	COMBO 8869 8870	 E0 Headspace E10 Headspace	8870E	E10 Headspace
nonpt/ ptnonipm	BTP	COMBO 8869 8870	 E0 Headspace E10 Headspace	COMBO 8870 8871 8934	 E10 Headspace E15 Headspace E85 Evap
nonpt/ ptnonipm	BPS/RBT	8869	E0 Headspace	8869	E0 Headspace

The speciation of onroad VOC occurs within MOVES. MOVES takes into account fuel type and properties, emission standards as they affect different vehicle types and model years, and specific emission processes. A description of the actual fuel formulations for 2011 can be found in the 2011NEIv2 TSD. For 2017, see Section 4.3. Table 3-11 describes all of the M-profiles available to MOVES depending on the model year range, MOVES process (processID), fuel sub-type (fuelSubTypeID), and regulatory class (regClassID). Table 3-12 to Table 3-14 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.

Table 3-11. 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

Profile	Profile Description	Model Years	ProcessID	FuelSubTypeID	RegClassID
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[14]	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[15]	10,40,41,42,46,47,48

Table 3-12. MOVES Process IDs

Process ID	Process Name
1	Running Exhaust
2	Start Exhaust
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

[14] 91 is the processed for APUs which are diesel engines not covered by the 2007 Heavey-Duty Rule, so the older technology applieds to all years.
[15] The profile assingments 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 combinate is already assigned to profile 8758.

Process ID	Process Name
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

Table 3-13. MOVES Fuel subtype IDs

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

Table 3-14. 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)

3.2.2 PM speciation

In addition to VOC profiles, the SPECIATE database also contains the $PM_{2.5}$ speciated into both individual chemical compounds (e.g., zinc, potassium, manganese, lead), and into the "simplified" $PM_{2.5}$ components used in the air quality model. We speciated $PM_{2.5}$ into the AE6 species associated with CMAQ 5.0.1 and later versions. While provided in the platform, they are not used in CAM_X but rather converted to the $PM_{2.5}$ species based on the cmaq2camx file presented in Table 3-4.

Table 3-15 shows the mapping of AE5 and AE6 for historical reference. The majority of the 2011 platform PM profiles come from the 911XX series which include updated AE6 speciation[16]. The 2011ek_cb6v2 and 2017ek_cb6v2 state-sector totals workbooks include state totals of the PM emissions for each state for the sectors that include PM.

Table 3-15. PM model species: AE5 versus AE6

Species name	Species description	AE5	AE6
POC	organic carbon	Y	Y
PEC	elemental carbon	Y	Y
PSO4	Sulfate	Y	Y
PNO3	Nitrate	Y	Y
PMFINE	unspeciated $PM_{2.5}$	Y	N
PNH4	Ammonium	N	Y
PNCOM	non-carbon organic matter	N	Y
PFE	Iron	N	Y
PAL	Aluminum	N	Y
PSI	Silica	N	Y
PTI	Titanium	N	Y
PCA	Calcium	N	Y
PMG	Magnesium	N	Y
PK	potassium	N	Y
PMN	Manganese	N	Y
PNA	Sodium	N	Y
PCL	Chloride	N	Y
PH2O	Water	N	Y
PMOTHR	$PM_{2.5}$ not in other AE6 species	N	Y

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

[16] The exceptions are 5674 (Marine Vessel – Marine Engine – Heavy Fuel Oil) used for cmv and 92018 (Draft Cigarette Smoke – Simplified) used in nonpt.

(e.g., PM_{10} and $PM_{2.5}$) and speciated PM (e.g., PEC, PFE, etc). SMOKE essentially calculates the PM components by using the appropriate EF without further speciation[17]. 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 that would otherwise be used in SMOKE via the profiles 91134 for brake wear and 91150 for tire wear:

```
POC = 0.4715 * PM25TIRE + 0.107 * PM25BRAKE
PEC = 0.22 * PM25TIRE + 0.0261 * PM25BRAKE
PNO3 = 0.0015 * PM25TIRE + 0.0016 * PM25BRAKE
PSO4 = 0.0311 * PM25TIRE + 0.0334 * PM25BRAKE
PNH4 = 0.00019 * PM25TIRE + 0.00003 * PM25BRAKE
PNCOM = 0.1886 * PM25TIRE + 0.0428 * PM25BRAKE
```

For California and Texas onroad emissions, adjustment factors were applied to SMOKE-MOVES to produce California and Texas adjusted model-ready files (see Section 2.3.1 for details). 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. Texas did supply speciated PM, but it was determined that Texas's PM speciation was very similar to the PM speciation from MOVES, so EPA-estimated speciation was preserved in Texas as well as California.

3.2.3 NO_X speciation

NO_X can be 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. For the mobile sources, except for onroad (including nonroad, cmv, rail, othon sectors), and for specific SCCs in othar and ptnonipm, the profile "HONO" splits NO_X into NO, NO_2, and HONO. Table 3-16 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 http://www.epa.gov/otaq/models/moves/documents/420r12022.pdf.

Table 3-16. 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

[17] 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/.

3.3 Temporal Allocation

Temporal allocation (i.e., temporalization) is the process of distributing aggregated emissions to a finer temporal resolution, thereby converting annual emissions to hourly emissions. 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. Temporalization takes these aggregated emissions and, if needed, distributes them to the month, and then distributes the monthly emissions to the day and the daily 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. A summary of emissions by temporal profile and sector for the 2011ek case is available from the reports area of the FTP site for the original 2011v6.3 platform ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/.

In SMOKE 3.7 and in the 2011v6.3 platform, more readable and flexible file formats are used for temporal profiles and cross references. The temporal factors applied to the inventory are selected using some combination of country, state, county, SCC, and pollutant. Table 3-17 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 3-17. Temporal settings used for the platform sectors in SMOKE for 2011en

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
ag	Annual	Yes	all	all	Yes
agfire	Monthly		week	week	Yes
beis	Hourly		n/a	all	Yes
cmv_c1c2	Annual	Yes	aveday	aveday	
cmv_c3	Annual	Yes	aveday	aveday	
rail	Annual	Yes	aveday	aveday	
nonpt	Annual	Yes	week	week	Yes
nonroad	Monthly		mwdss	mwdss	Yes
np_oilgas	Annual	Yes	week	week	Yes
onroad	Annual & monthly[1]		all	all	Yes
onroad_ca_adj	Annual & monthly[1]		all	all	Yes
othafdust_adj	Annual	Yes	week	all	
othar	Annual & monthly	yes	week	week	
othon	Monthly		week	week	
othpt	Annual & monthly	yes	mwdss	mwdss	
pt_oilgas	Annual	yes	mwdss	mwdss	Yes

Platform sector short name	Inventory resolutions	Monthly profiles used?	Daily temporal approach	Merge processing approach	Process Holidays as separate days
ptegu	Daily & hourly		all	all	Yes
ptnonipm	Annual	yes	mwdss	mwdss	Yes
ptfire	Daily		all	all	Yes
ptfire_mxca	Daily		all	all	Yes
rwc	Annual	no	met-based	all	Yes

[1] Note the annual and monthly "inventory" actually refers to the activity data (VMT and VPOP) for onroad. The actual emissions are computed on an hourly basis.

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 temporalization 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, 2011, which is intended to mitigate the effects of initial condition concentrations. The ramp-up period was 10 days (December 22-31, 2010). For most sectors, emissions from December 2011 were used to fill in surrogate emissions for the end of December 2010. In particular, December 2011 emissions (representative days) were used for December 2010. For biogenic emissions, December 2010 emissions were processed using 2010 meteorology.

3.3.1 Use of FF10 format for finer than annual emissions

The Flat File 2010 format (FF10) inventory format used by SMOKE provides a more consolidated format for monthly, daily, and hourly emissions inventories than prior formats supported. Previously, processing monthly inventory data required the use of 12 separate inventory files. 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 temporalization applied to it; rather, it should only have month-to-day and diurnal temporalization. This becomes particularly important when specific sectors have a mix of annual, monthly, daily, and/or hourly inventories. The flags that control temporalization 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 agfire, nonroad, onroad activity data, and ptegu.

3.3.2 Nonroad temporalization (nonroad)

The only change to the temporal allocation process in the 2011el platform was the monthly temporalization of California nonroad emissions in 2023. In prior platforms, annual nonroad emissions in California were allocated to monthly values based on monthly distributions of the National Mobile Inventory Model (NMIM) emissions at the SCC7 level. This resulted in unrealistic monthly temporalization for some sub-SCC7 categories, for example, snowmobile emissions in the summer. A different set of monthly temporal profiles was applied to California nonroad emissions for 2023 with assignments based on full SCC, not SCC7, so that snowmobiles and other specific categories receive a more realistic monthly profile.

For the 2011en platform, temporal profile updates were implemented for nonroad emissions as shown in Figure 3-3 and Figure 3-4. Specifically, construction and commercial lawn and garden day-of-week profiles were updated from profile 18 to profile 19 while residential lawn and garden was unchanged from profile 9 and agriculture was unchanged from profile 18. Hour-of-day profiles for all four of these categories were updated from profile 26 to the following new assignments: construction now uses profile 26a, commercial lawn and garden uses 25a, residential lawn and garden uses 27, and agriculture uses 26a. In general, the goal of these updates was to put fewer emissions in overnight hours and to refine the weekday/weekend split for these source categories.

Figure 3-3. Original and updated nonroad day-of-week profiles

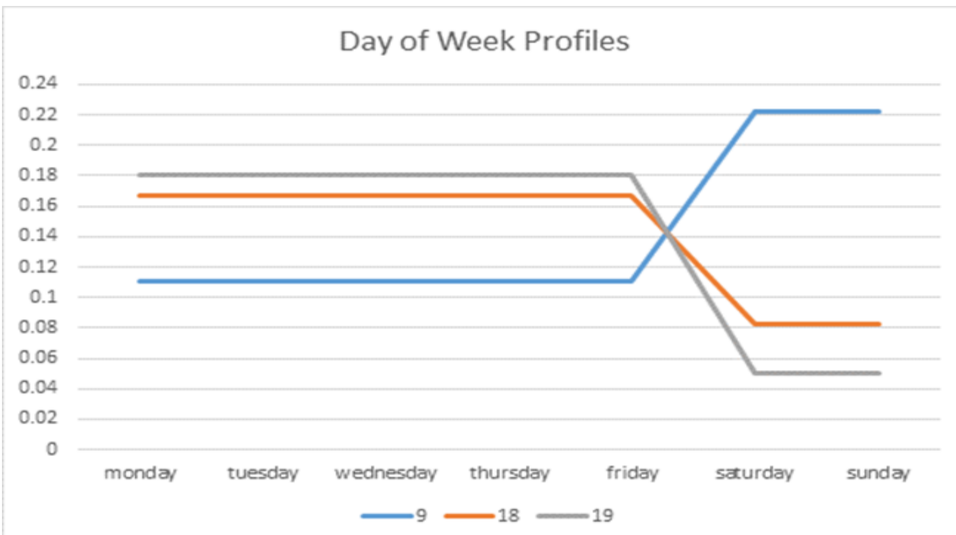
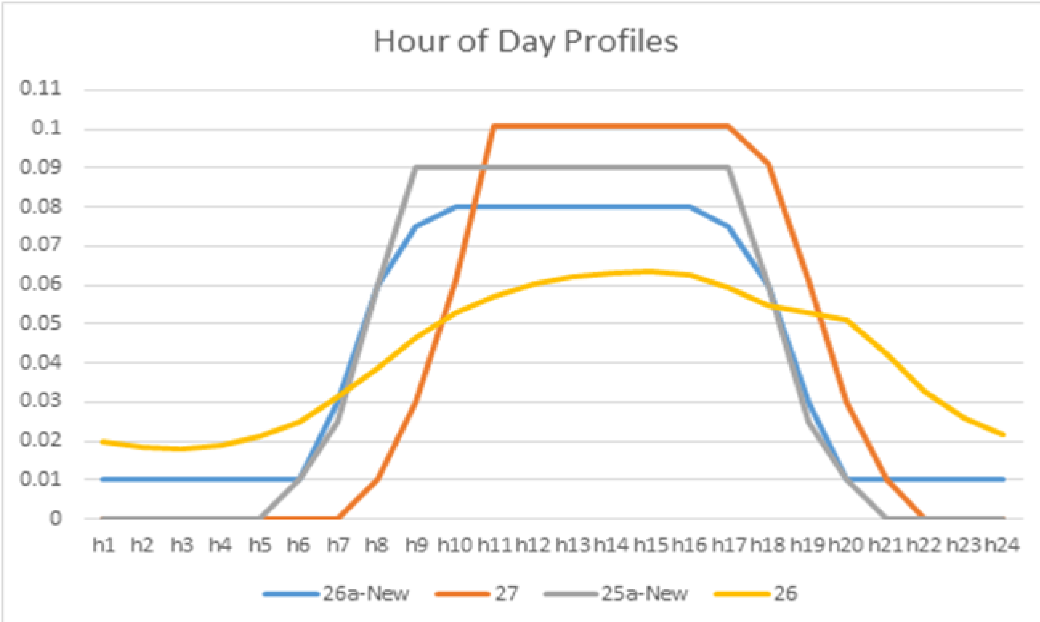


Figure 3-4. Original and updated nonroad hour-of-day profiles



3.3.3 Electric Generating Utility temporal allocation (ptegu)

<u>Base year temporal allocation of EGUs</u>

The 2011NEIv2 annual EGU emissions not matched to CEMS sources are allocated to hourly emissions using the following 3-step methodology: annual value to month, month to day, and day to hour. In the 2011v6.3 platforms, the CEMS data were processed using a tool that reviewed the data quality flags that indicate the data were not measured. Unmeasured data can cause erroneously high values in the CEMS data. If the data were not measured at specific hours, and those values were found to be more than three times the annual mean for that unit, the data for those hours were replaced with annual mean values (Adelman et al., 2012). These adjusted CEMS data were then used for the remainder of the temporalization process described below (see Figure 3-5 for an example). Winter and summer seasons are included in the development of the diurnal profiles as opposed to using data for the entire year because analysis of the hourly CEMS data revealed that there were different diurnal patterns in winter versus summer in many areas. Typically, a single mid-day peak is visible in the summer, while there are morning and evening peaks in the winter as shown in Figure 3-6.

The temporal allocation procedure is differentiated by whether or not the source could be directly matched to a CEMS unit via ORIS facility code and boiler ID. Prior to temporal allocation, as many sources as possible were matched to CEMS data via ORIS facility code and boiler ID. Units were considered matches if the FIPS state/county code matched, the facility name was similar, and the NO_x and SO_2 emissions were similar. The EIS stores a base set of previously matched units via alternate facility and unit IDs. Additions to these matches were made for the 2011v6.3 platform due to additional specificity available in SMOKE but not in EIS, and also based on comments. For any units that are matched, the ORIS facility and boiler ID columns of the point FF10 inventory files are filled with the information on the rows for the corresponding NEI unit. Note that for units matched to CEMS data, annual totals of their emissions may be different than the annual values in 2011NEIv2 because the CEMS data actually replaces the 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.

Figure 3-5. Eliminating unmeasured spikes in CEMS data

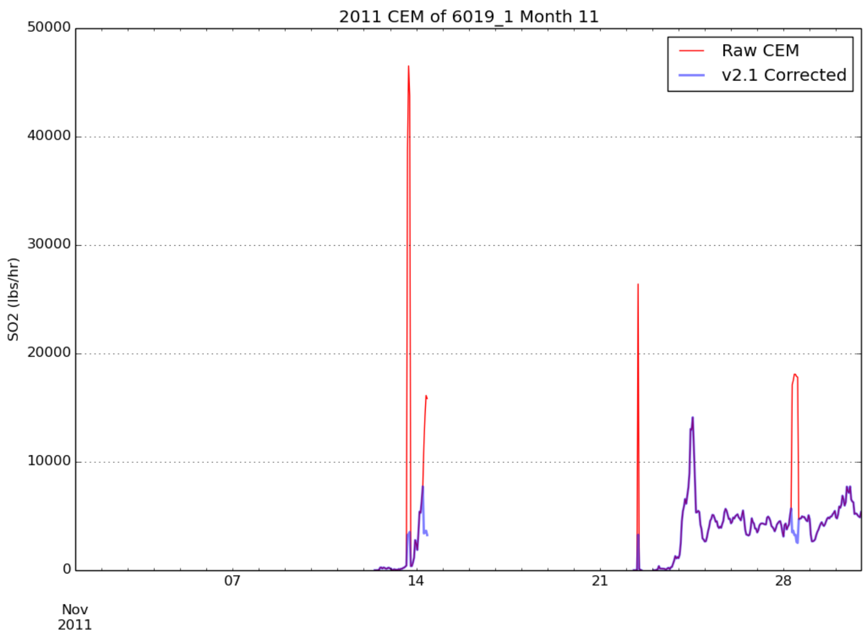
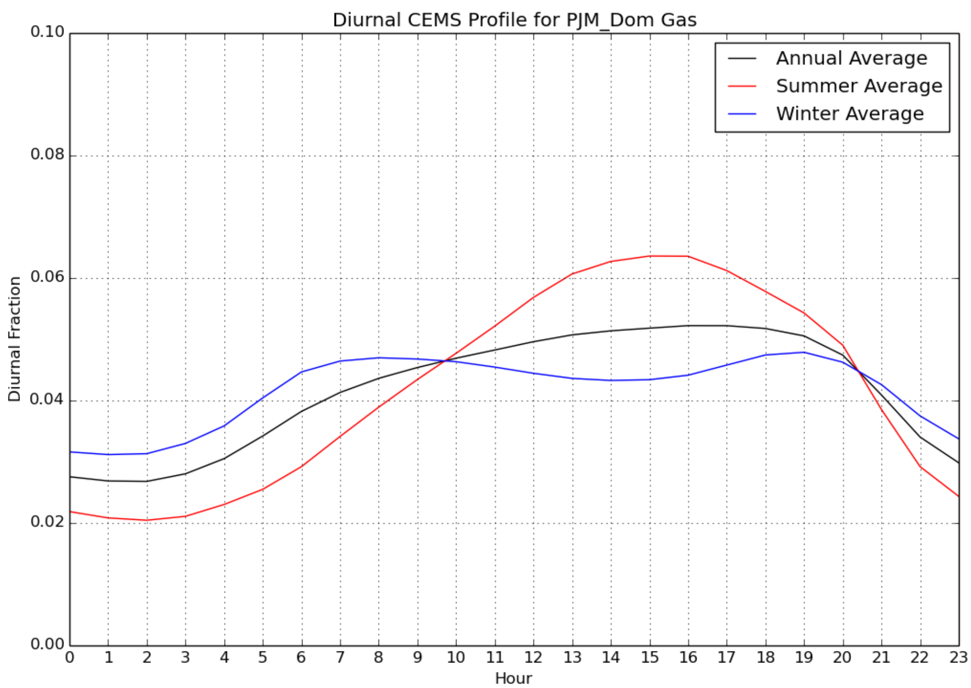
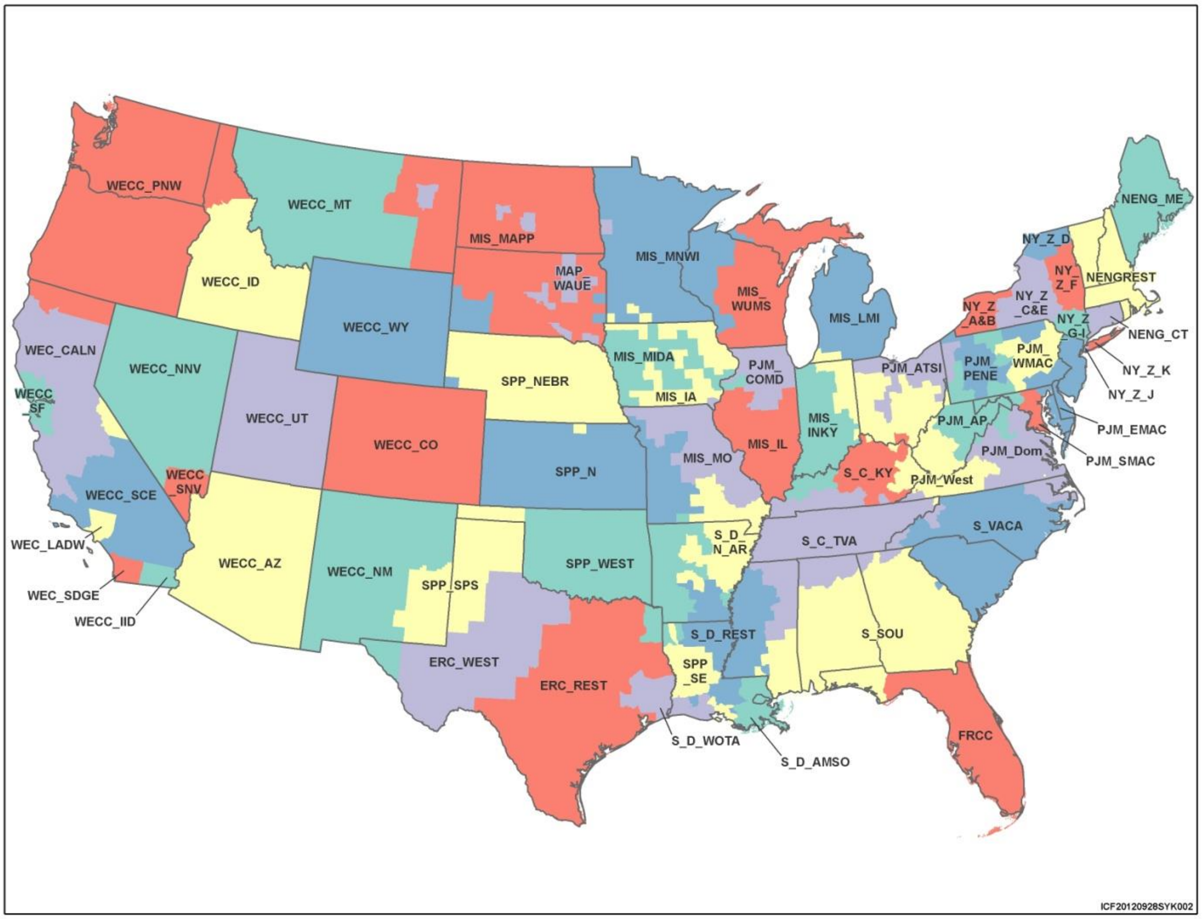


Figure 3-6. Seasonal diurnal profiles for EGU emissions in a Virginia Region



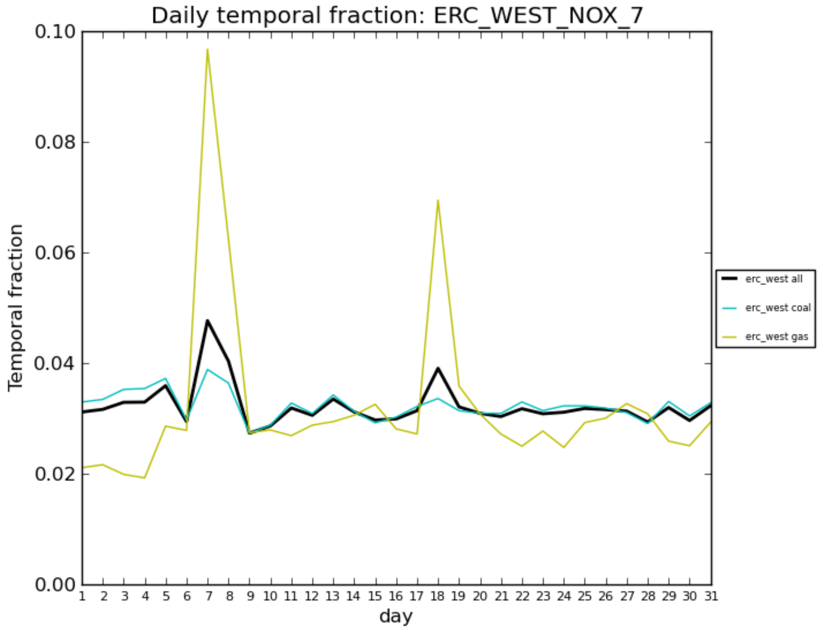
For sources not matched to CEMS units, the allocation of annual emissions to months and then days are done outside of SMOKE and then daily emissions are output to day-specific inventory files. For these units, the allocation of the inventory annual emissions to months is done using average fuel-specific season-to-month factors generated for each of the 64 IPM regions shown in Figure 3-7. These factors are based on 2011 CEMS data only. In each region, separate factors were developed for the fuels: coal, natural gas, and "other," where the types of fuels included in "other" vary by region. Separate profiles were computed for NO_x, SO_2, and heat input. An overall composite profile was also computed and used when there were no CEMS units with the specified fuel in the region containing the unit. For both CEMS-matched units and units not matched to CEMS, NO_x and SO_2 CEMS data are used to allocate NO_x and SO_2 emissions to monthly emissions, respectively, while heat input data are used to allocate emissions of all other pollutants and to allocate emissions of all pollutants from monthly to daily emissions.

Figure 3-7. IPM Regions in Version 5.16



Daily temporal allocation of units matched to CEMS was performed using a procedure similar to the approach to allocate emissions to months in that the CEMS data replaces the inventory data for each pollutant. For units without CEMS data, emissions were allocated from month to day using IPM-region and fuel-specific average month-to-day factors based on the 2011 CEMS data. Separate month-to-day allocation factors were computed for each month of the year using heat input for the fuels coal, natural gas, and "other" in each region. For both CEMS and non-CEMS matched units, 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. An example of month-to-day profiles for gas, coal, and an overall composite for a region in western Texas is shown in Figure 3-8.

Figure 3-8. Month-to-day profiles for different fuels in a West Texas Region



For units matched to CEMS data, hourly emissions use the hourly CEMS values for NO_x and SO_2, while other pollutants are allocated according to heat input values. For units not matched to CEMS data, temporal profiles from days to hours are computed based on the season-, region- and fuel-specific average day-to-hour factors derived from the CEMS data for those fuels and regions using the appropriate subset of data. For the unmatched units, CEMS heat input data are used to allocate *all* pollutants (including NO_x and SO_2) because the heat input data was generally found to be more complete than the pollutant-specific data. SMOKE then allocates the daily emissions data to hours using the temporal profiles obtained from the CEMS data for the analysis base year (i.e., 2011 in this case).

In the 2011en platform, MWCs and cogeneration units were specified to use flat hourly 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 flat hourly temporal profile applied by SMOKE.

<u>Future year temporal allocation of EGUs</u>

For future year temporal allocation of unit-level EGU emissions, estimates of average winter (representing October through April) and average summer (representing May through September) values were provided for all units that submitted CEMS data to EPA as part of the Cross-State Air Pollution Rule and Acid Rain Programs. For the 2023el case, the seasonal emissions were produced by postprocessing of outputs from the Integrated Planning Model (IPM), while for the 2023en case the unit-level emissions were developed using an engineering analysis approach (see Section 4.1 for more details). For both cases, the unit-level data was 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., 2011) is used as much as possible to temporally allocate the EGU emissions. In the 2011v6.3 platforms, temporal profiles are developed in SMOKE temporal profile formats instead of the earlier method of some temporal allocation being done by SMOKE and some by external programs.

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 two seasons: summer (May through September) and winter (October through April). 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 the IPM National Electric Energy Database System (NEEDS) database to the stack parameter and facility, unit, release point, and process identifiers used in the NEI. The cross reference also maps sources to the hourly CEMS data used to temporally allocate the emissions in the base year air quality modeling. For the 2023el case, the v5.16 cross reference information along with other key inputs to the flat file generation process are in the file IPM5.16_FlatFile_Inputs.xlsx that is available in the reports section of the 2011v6.3 platform FTP area: ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/reports/. Note that for 2023en, this file is not used because the 2023en EGU emissions were not generated using IPM.

For units that had 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 and average winter day emissions by the number of days in the respective month. 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. In 2023en, units without CEMS data only had annual emissions specified. For those units, monthly temporalization factors were generated by source and pollutant based on 2011en emissions. These factors were then applied to the 2023en annual emissions to create the 2023en monthly emissions.

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 2011 CEMS data to develop monthly, daily, and hourly profiles, the CEMS data were processed through a tool that found data quality flags that indicated the data were measured. 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 match to the NEI sources, the emissions are temporalized based on the 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 generated for each of the 64 IPM regions shown in Figure 3-7. 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 2011. The fuels used for creating the profiles for a region are coal, natural gas, and other, where the other fuels used include oil and wood and vary by region. Separate profiles are computed for NO_x, SO_2, and heat input. 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.

The monthly emission values in the Flat File are first reallocated across the months in that season to align the month-to-month emission pattern at each stack with historic seasonal emission patterns[18]. 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 are 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. Average profiles are 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[19]; (2) CEMS data are only available for a limited number of hours in that base year; (3) units change fuels in the future year; (4) the unit is new in the future year; (5) when there are no CEMS data for one season in the base year but IPM runs the unit during both seasons; or (6) 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 are 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 those fuels and regions using only heat input data for that season. Only heat input is used because it is the variable that is the most complete in the CEMS data. SMOKE uses these profiles to allocate the daily emissions data to hours.

The emissions from units for which unit-specific profiles are not used are 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 64 IPM regions revealed that there were differences in the temporal patterns of historic emission data that correlate with fuel type (e.g., coal, gas, 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 IPM regional location. For temporal allocation of emissions at these units,

[18] For example, the total emissions for a unit in May would not typically be the same as the total emissions for the same unit in July, even though May and July are both in the summer season and the number of days in those months is the same. This is because the weather changes over the course of each season, and thus the operating behavior of a specific unit can also vary throughout each season. Therefore, part of the temporal allocation process is intended to create month-specific emissions totals that reflect this intra-seasonal variation in unit operation and associated emissions.
[19] In such instances, the EPA does not use that unit's CEMS data for temporal allocation in order to avoid assigning large increases in emissions over short time periods in the unit's hourly emission profile.

Figure 3-8 provides an example of daily coal, gas, and composite profiles in one IPM 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[20]. Figure 3-6 provides an example of seasonal profiles that allocate daily emissions to hours in one IPM 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 are matched to units in the IPM output, the base year CEMS data are scaled so that their seasonal emissions match the IPM-projected totals. In particular, the fraction of the unit's seasonal emissions in the base year is computed for each hour of the season, and then applied to the seasonal emissions in the future year. Any pollutants other than NO_x and SO_2 are temporally allocated using heat input as a surrogate. Distinct factors are used for the fuels coal, natural gas, and "other." Through the temporal allocation process, the future year emissions have the same temporal pattern as the base year CEMS data while the future-year seasonal total emissions for each unit match the future-year unit-specific projection for each season (see example in Figure 3-9).

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 2011-2014 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 was 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 3-10).

[20] The EPA also uses an overall composite profile across all fuels for each IPM region in instances where a unit is projected to burn a fuel for which the EPA cannot construct an average emission profile (because there were no other units in that IPM region whose historic CEMS data represent emissions from burning that fuel).

Figure 3-9. Future year emissions follow pattern of base year emissions

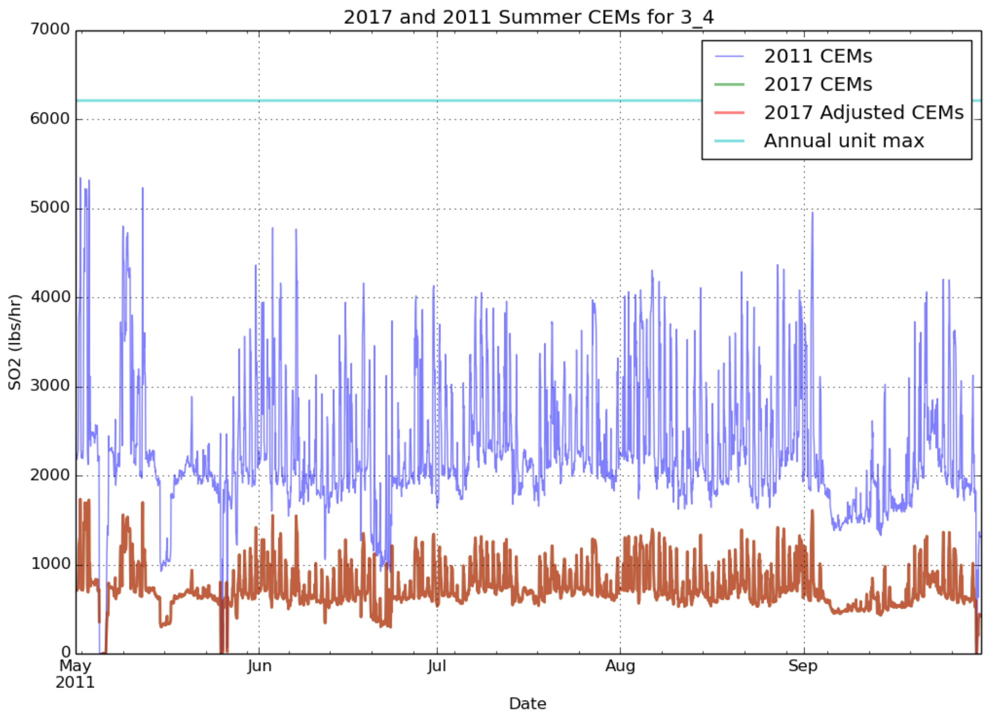
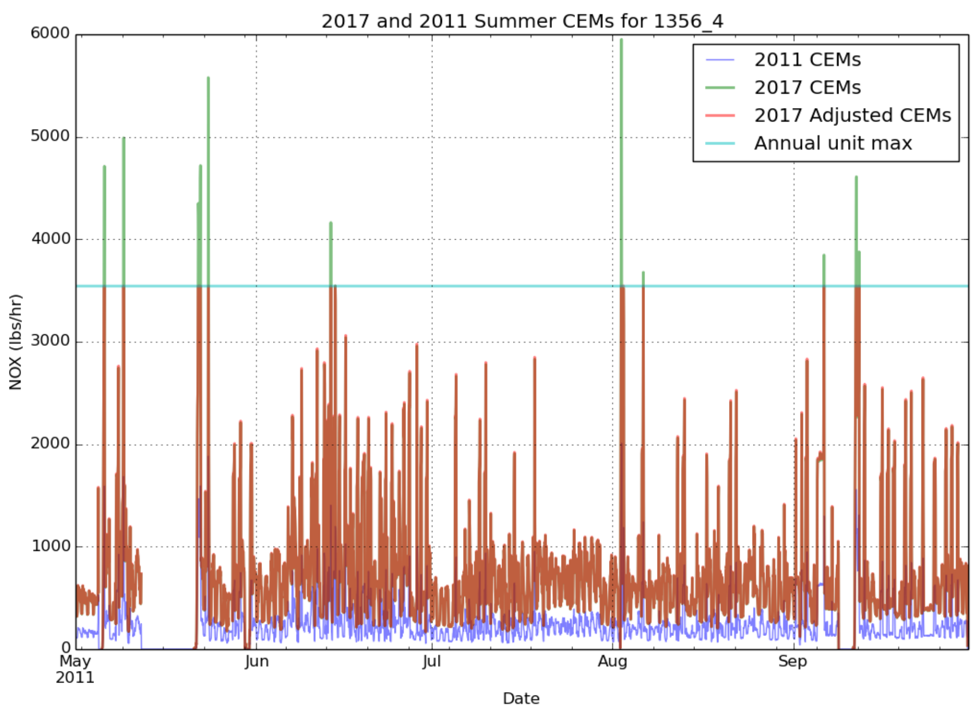


Figure 3-10. Excess emissions apportioned to hours less than maximum



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 2011-2014 maximum emissions level. For these units, the *regional* fuel-specific average profile was applied to all pollutants, including heat input, for that season (see example in Figure 3-11). An exception to this is if the fuel for that unit is not gas or coal. In that case, the composite (non-fuel-specific) profile was used for that unit. This is because many sources that used "other" fuel profiles had very irregular shapes due to a small number of sources in the region, and the allocated emissions frequently still exceeded the 2011-2014 maximum. Note that it was not possible for SMOKE to use regional profiles for some pollutants and adjusted CEMS data for other pollutants for the same unit/season, therefore, all pollutants are assigned to regional profiles when regional profiles are needed. Also note that for some units, some hours still exceed the 2011-2014 annual maximum for the unit even after regional profiles were applied (see example in Figure 3-12).

For more information on the development of IPM emission estimates for the 2011el case and the temporalization of those, see the IPM 5.16 section of https://www.epa.gov/airmarkets/clean-air-markets-power-sector-modeling, in particular the Air Quality Modeling Flat File Documentation and accompanying inputs.

Figure 3-11. Adjustment to Hours Less than Maximum Not Possible so Regional Profile Applied

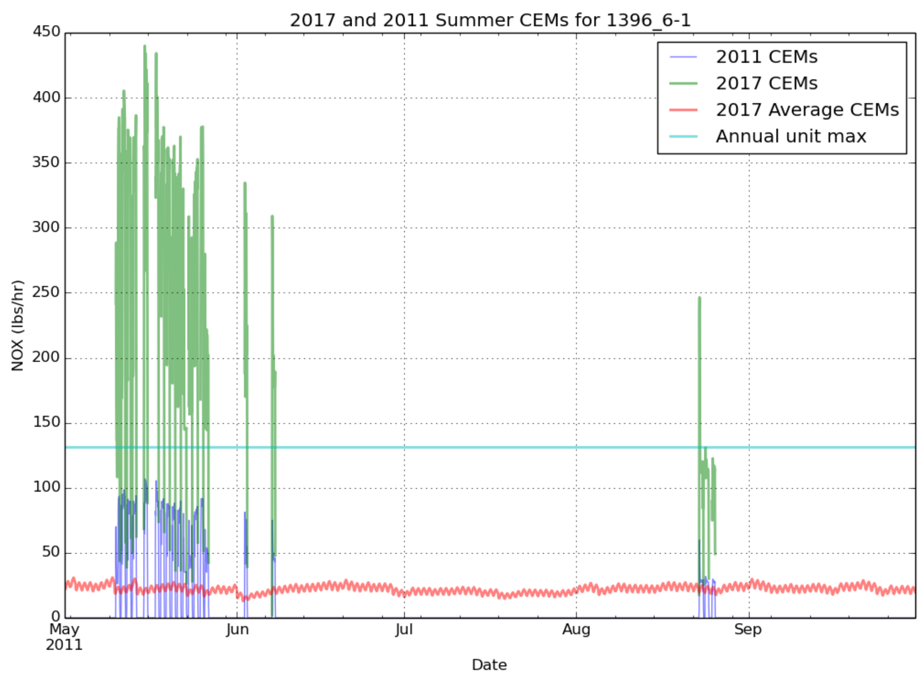
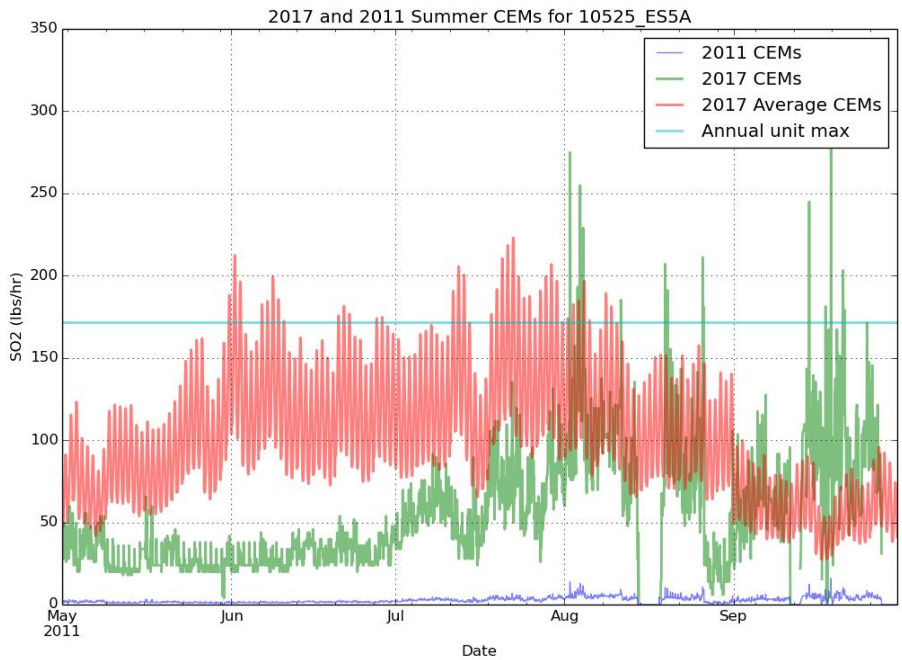


Figure 3-12. Regional Profile Applied, but Exceeds Maximum in Some Hours



3.3.4 Residential Wood Combustion Temporalization (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 method for temporalization 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 temporalization.

The SMOKE program GenTPRO provides a method for developing meteorology-based temporalization. Currently, the program can utilize three types of temporal algorithms: annual-to-day temporalization for residential wood combustion (RWC); month-to-hour temporalization for agricultural livestock NH_3; and a generic meteorology-based algorithm for other situations. For the 2011 platform, meteorological-based temporalization was used for portions of the rwc sector and for livestock within the ag sector.

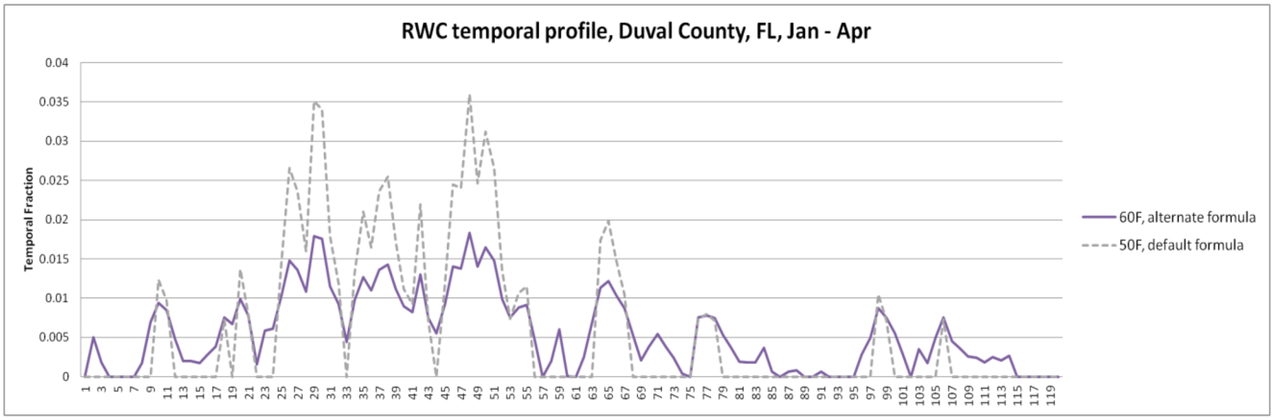
GenTPRO reads in gridded meteorological data (output from MCIP) along with spatial surrogates, and uses the specified algorithm to produce a new temporal profile that can be input into SMOKE. The meteorological variables and the resolution of the generated temporal profile (hourly, daily, etc.) depend 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/3.7/html/ch05s03s06.html, respectively.

As of the 2011v6.2 platform and in SMOKE 3.6.5, the temporal profile format was updated. GenTPRO now produces separate files including the monthly temporal profiles (ATPRO_MONTHLY) and day-of-month temporal profiles (ATPRO_DAILY), instead of a single ATPRO_DAILY with day-of-year temporal profiles as it did in SMOKE 3.5. The results are the same either way, so the temporal profiles themselves are effectively the same in 2011v6.2 as they were in 2011v6.0 since the meteorology is the same, but they are formatted differently.

For the RWC algorithm, GenTPRO uses the daily minimum temperature to determine the temporal allocation of emissions to days. 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.

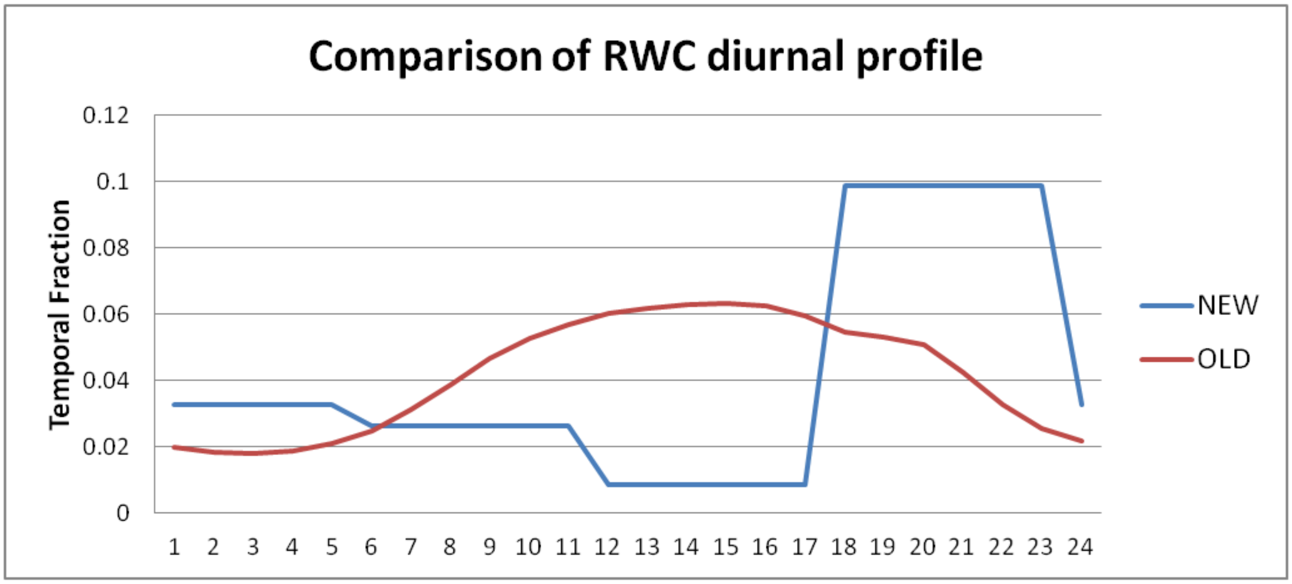
Figure 3-13 illustrates the impact of changing the temperature threshold for a warm climate county. The plot shows the temporal fraction by day for Duval County, Florida, for the first four months of 2007. The default 50 ˚F threshold creates large spikes on a few days, while the 60 ˚F threshold dampens these spikes and distributes a small amount of emissions to the days that have a minimum temperature between 50 and 60 ˚F.

Figure 3-13. Example of RWC temporalization in 2007 using a 50 versus 60 ˚F threshold



The diurnal profile for used for most RWC sources (see Figure 3-14) 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 (see http://www.marama.org/publications_folder/ResWoodCombustion/Final_report.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 day of the week and found that the new RWC profile generally tracked the concentration based temporal patterns.

Figure 3-14. RWC diurnal temporal profile



The temporalization for "Outdoor Hydronic Heaters" (i.e., "OHH," SCC=2104008610) and "Outdoor wood burning device, NEC (fire-pits, chimneas, etc.)" (i.e., "recreational RWC," SCC=21040087000) were updated because the meteorological-based temporalization 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.

The diurnal profile for OHH, shown in Figure 3-15, is based on a conventional single-stage heat load unit burning red oak in Syracuse, New York. As shown in Figure 3-16, 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 temporalization for OHH as well as recreational RWC were computed from the MDNR 2008 survey and are illustrated in Figure 3-17. 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 3-15. Diurnal profile for OHH, based on heat load (BTU/hr)

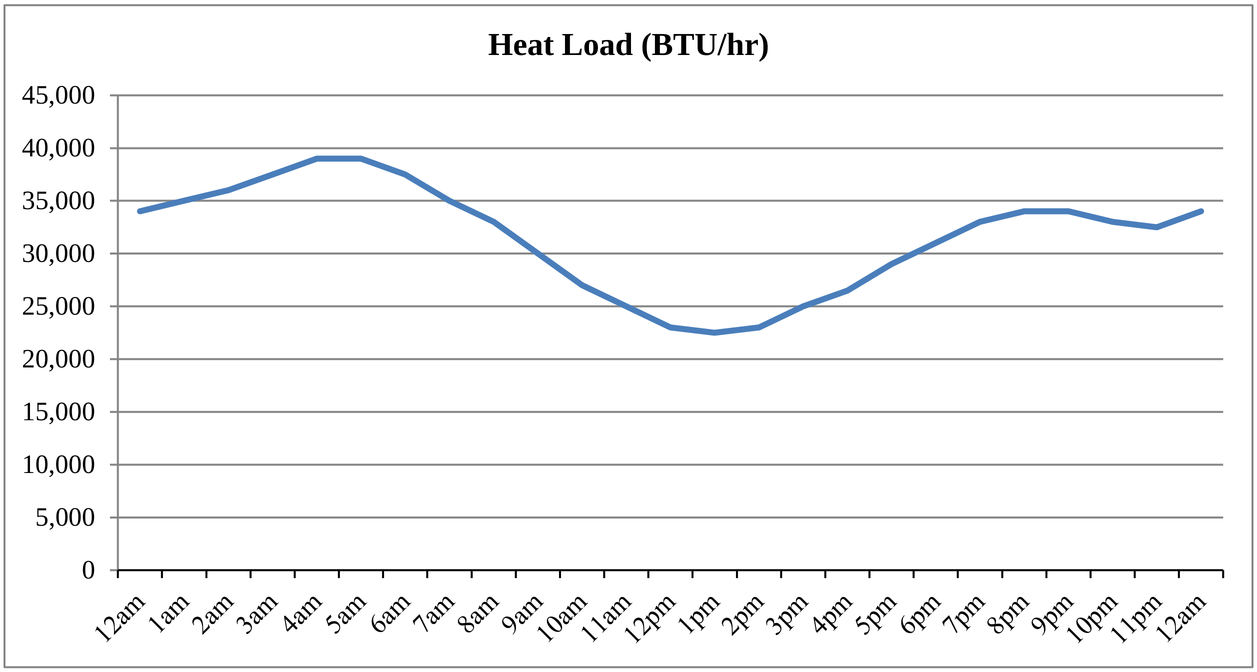


Figure 3-16. Day-of-week temporal profiles for OHH and Recreational RWC

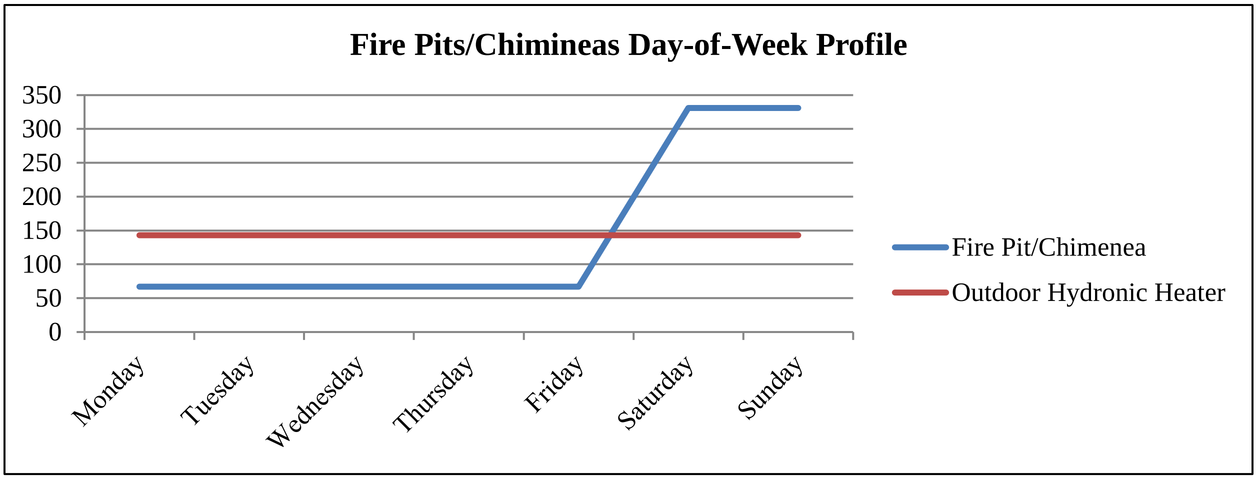
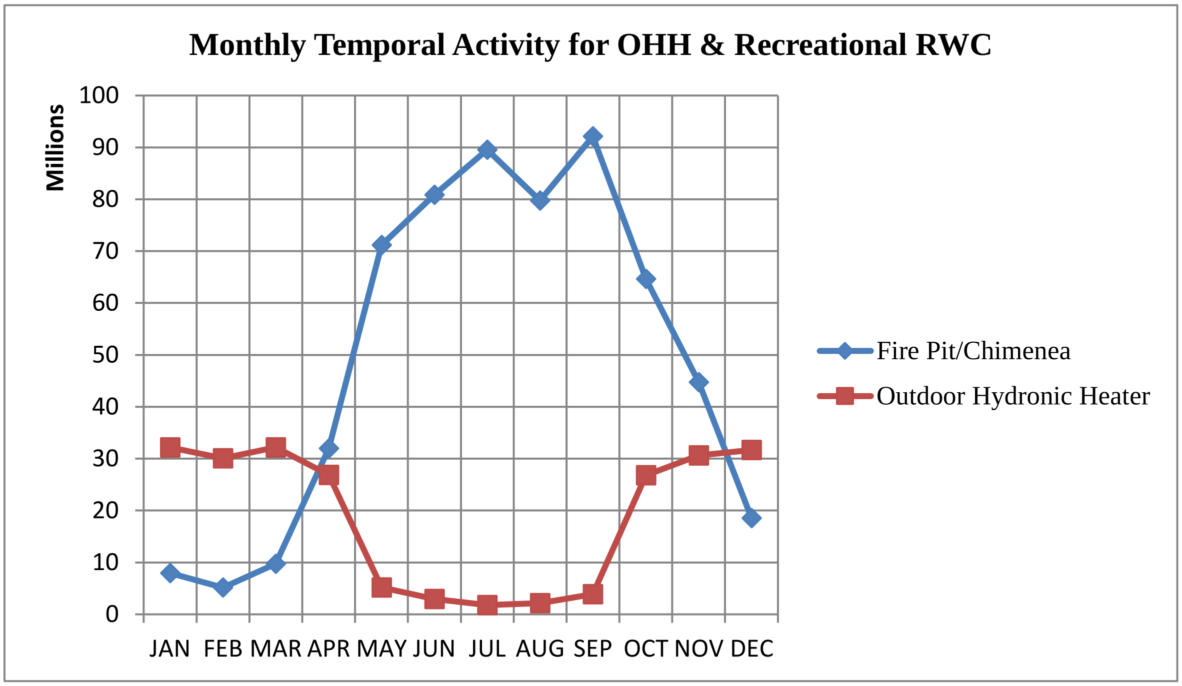


Figure 3-17. Annual-to-month temporal profiles for OHH and recreational RWC



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 NH3 emission variations from livestock as a function of ambient temperature, aerodynamic resistance, and wind speed. The equations are:

$$E_{i,h} = [161500/T_{i,h} \text{ x } e^{(-1380/T_{i,h})}] \text{ x } AR_{i,h}$$

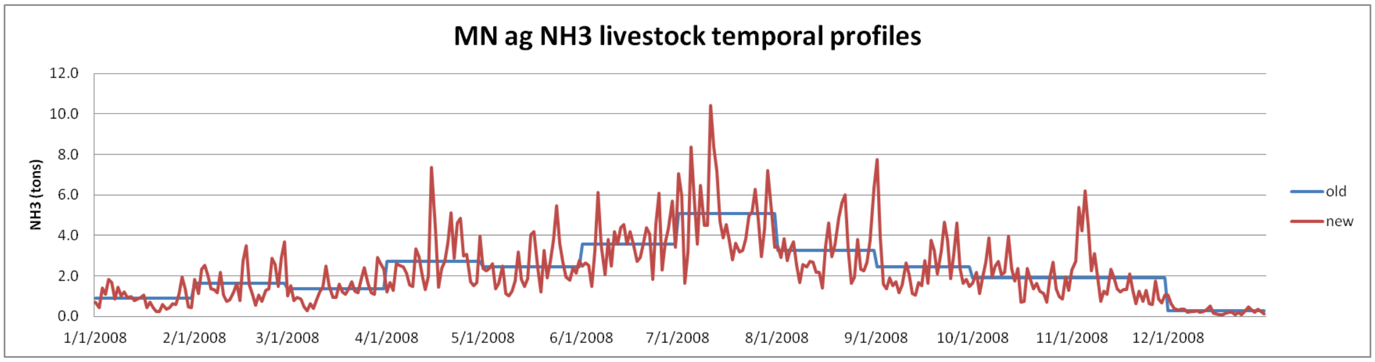
$$PE_{i,h} = E_{i,h} / \text{Sum}(E_{i,h})$$

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*
- $V_{i,h}$ = Wind speed (meter/sec) in county *i* (minimum wind speed is 0.1 meter/sec)
- $AR_{i,h}$ = 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 3-18 compares the daily emissions for Minnesota from the "old" approach (uniform monthly profile) with the "new" approach (GenTPRO generated month-to-hour profiles). Although the GenTPRO profiles show daily (and hourly variability), the monthly total emissions are the same between the two approaches.

Figure 3-18. Example of animal NH_3 emissions temporalization approach, summed to daily emissions



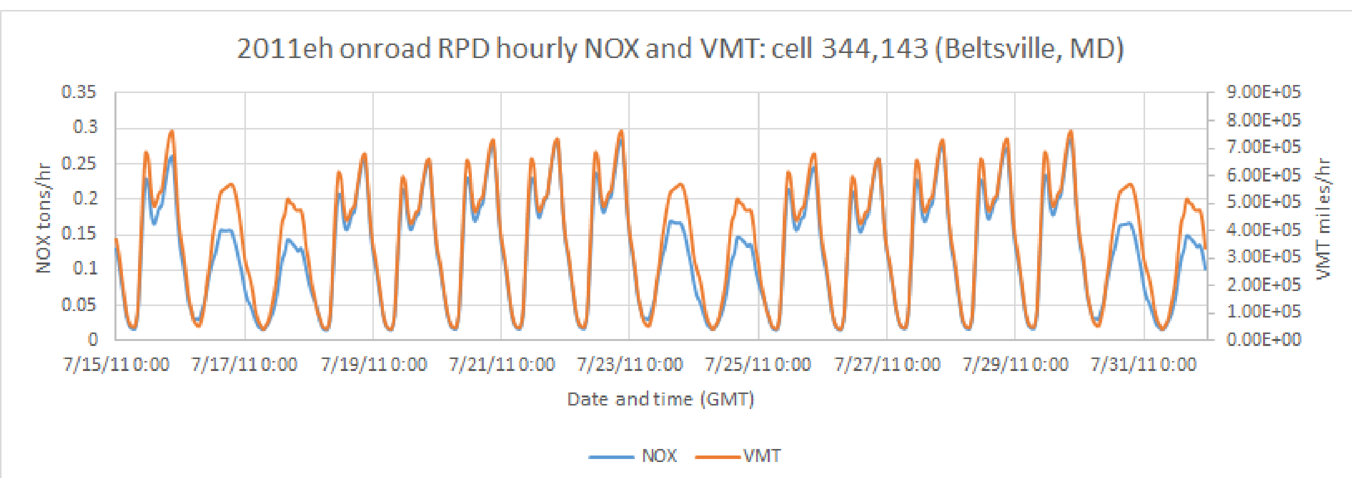
3.3.6 Onroad mobile temporalization (onroad)

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

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) directly. 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. In the 2011 platform (and for the 2011NEIv2), RPP was updated to use the gridded minimum and maximum temperature for the day. This more spatially resolved temperature range produces more accurate emissions for each grid cell. The combination of these four processes (RPD, RPV, RPH, and RPP) is the total onroad sector emissions. The onroad sector show a strong meteorological influence on their temporal patterns (see the 2011NEIv2 TSD for more details).

Figure 3-19 illustrates the temporalization of the onroad sector and the meteorological influence via SMOKE-MOVES. Similar temporalization is done for the VMT in SMOKE-MOVES, but the meteorologically varying emission factors add an additional variation on top of the temporalization.

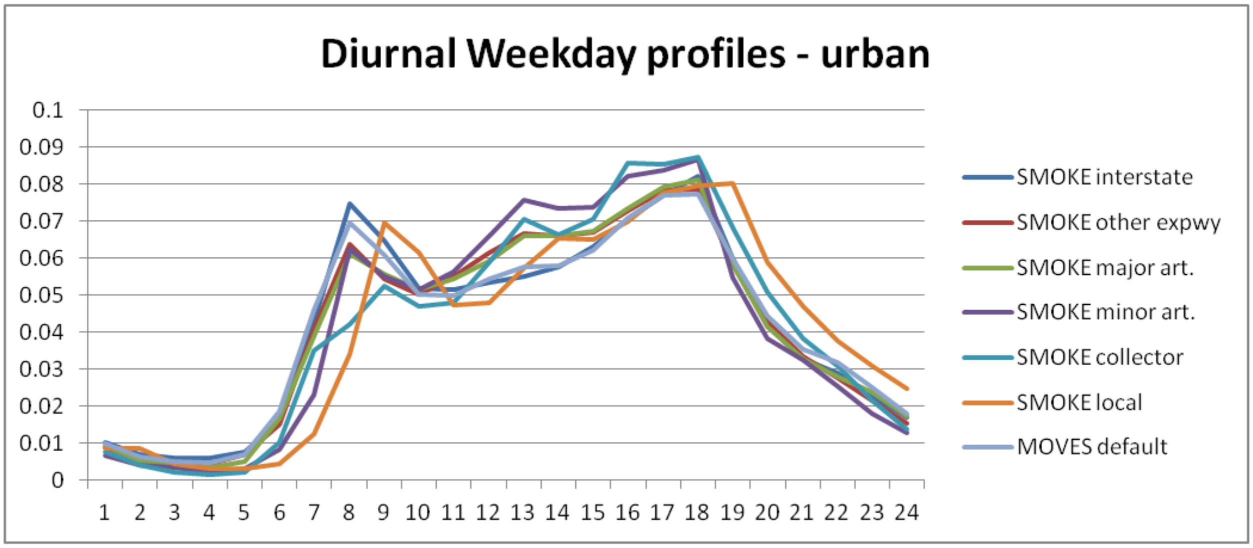
Figure 3-19. Example of SMOKE-MOVES temporal variability of NO_X emissions



For the onroad sector, the "inventories" referred to in Table 3-17 actually consist of activity data, not emissions. For RPP and RPV processes, the VPOP inventory is annual and does not need temporalization. For RPD, the VMT inventory is monthly and was temporalized to days of the week and then to hourly VMT 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. Unlike other sectors, 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 from 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 temporalization of VMT changes. For RPH, the HOTELING inventory is monthly and was temporalized to days of the week and to hour of the day through temporal profiles. This is an analogous process to RPD except that speed is not included in the calculation of RPH.

In previous platforms, the diurnal profile for VMT[21] varied by road type but not by vehicle type (see Figure 3-20). These profiles were used throughout the nation.

Figure 3-20. Previous onroad diurnal weekday profiles for urban roads



Diurnal profiles that could differentiate by vehicle type as well as by road type and would potentially vary over geography were desired. In the development of the 2011v6.0[22] platform, the EPA updated these profiles to include information submitted by states in their MOVES county databases (CDBs). The 2011NEIv2 process provided an opportunity to update these diurnal profile with new information submitted by states, to supplement the data with additional sources, and to refine the methodology.

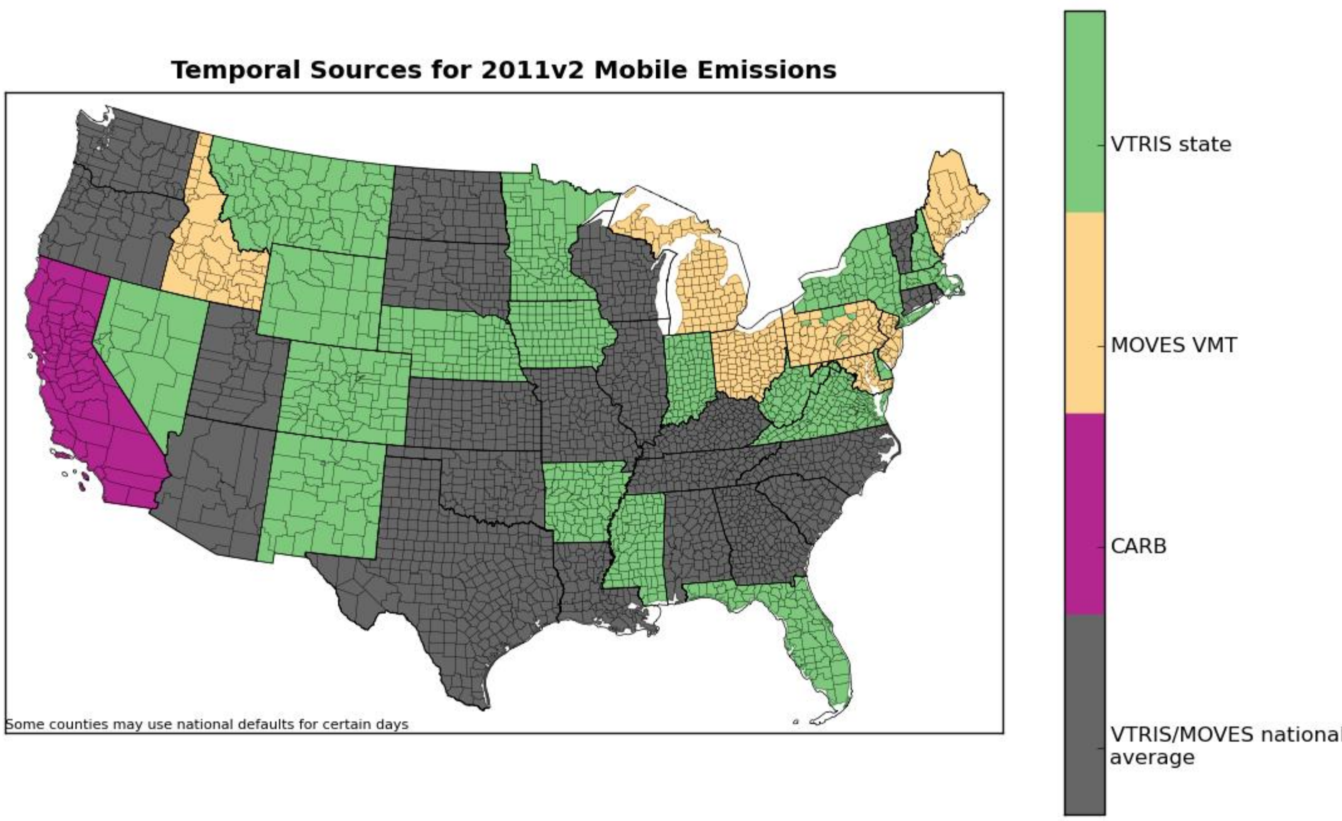
States submitted MOVES county databases (CDBs) that included information on the distribution of VMT by hour of day and by day of week[23] (see the 2011NEIv2 TSD for details on the submittal process for onroad). The EPA mined the state submitted MOVES CDBs for non-default diurnal profiles[24]. The list

[21] These profiles were used in the 2007 platform and proceeding platforms.
[22] These profiles that were generated from MOVES submittals only were used for the v6 and v6.1 platforms. See their respective TSDs for more details.
[23] The MOVES tables are the hourvmtfraction and the dayvmtfraction.
[24] Further QA was done to remove duplicates and profiles that were missing two or more hours. If they were missing a single hour, the missing hour could be calculated by subtracting all other hours fractions from 1.

of potential diurnal profiles was then analyzed to see whether the profiles varied by vehicle type, road type, weekday versus weekend, and by county within a state. For the MOVES diurnal profiles, the EPA only considered the state profiles that varied significantly by both vehicle and road types. Only those profiles that passed this criteria were used in that state or used in developing default temporal profiles. The Vehicle Travel Information System (VTRIS) is a repository for reported traffic count data to the Federal Highway Administration (FHWA). The EPA used 2012 VTRIS data to create additional temporal profiles for states that did not submit temporal information in their CDBs or where those profiles did not pass the variance criteria. The VTRIS data were used to create state specific diurnal profiles by HPMS vehicle and road type. The EPA created distinct diurnal profiles for weekdays, Saturday and Sunday along with day of the week profiles[25].

The EPA attempted to maximize the use of state and/or county specific diurnal profiles (either from MOVES or VTRIS). Where there was no MOVES or VTRIS data, then a new default profile would be used (see below for description of new profiles). This analysis was done separately for weekdays and for weekends and, therefore, some areas had submitted profiles for weekdays but defaults for weekends. The result was a set of profiles that varied geographically depending on the source of the profile and the characteristics of the profiles (see Figure 3-21).

Figure 3-21. Use of submitted versus new national default profiles

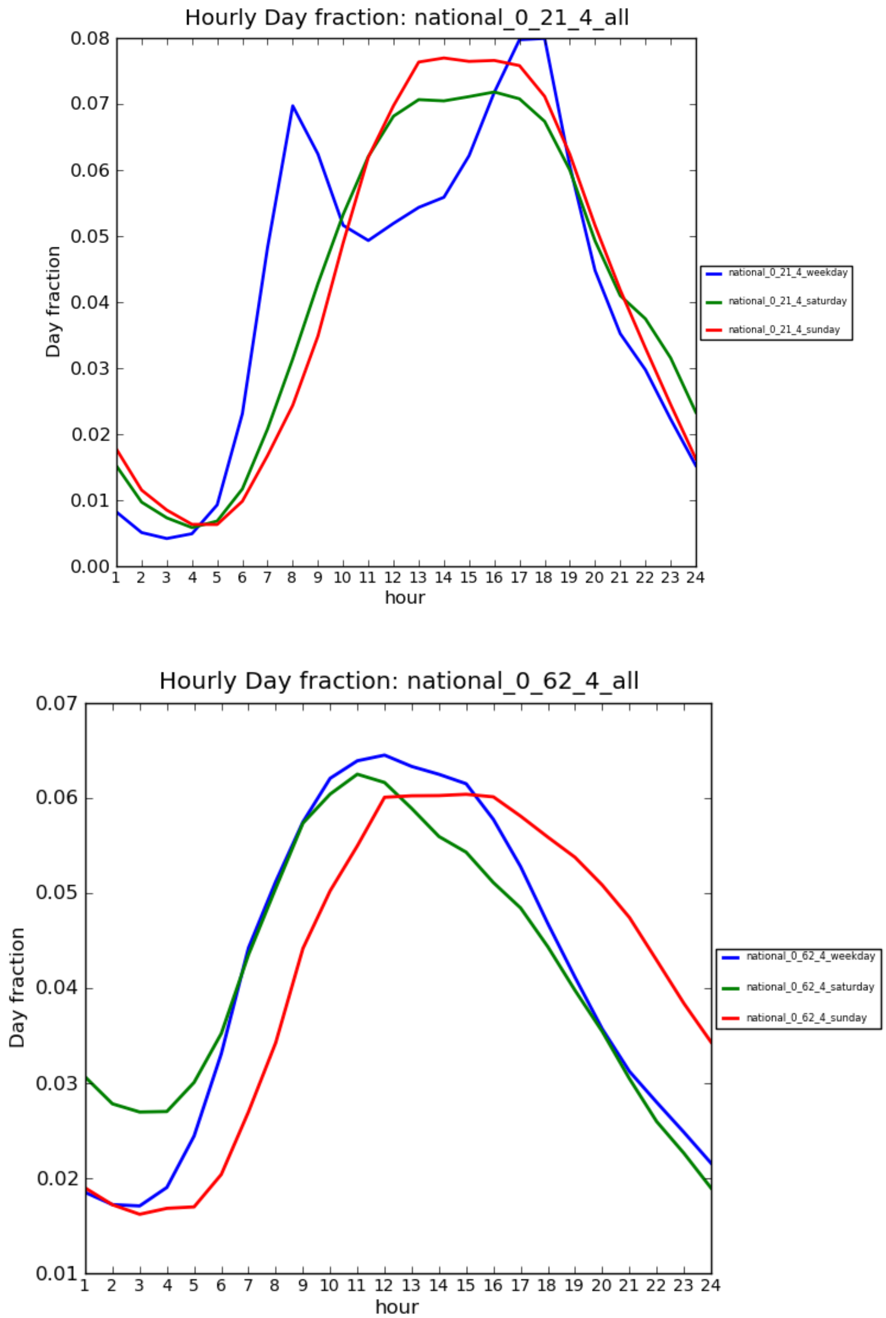


A new set of diurnal profiles was developed for the 2011v6.2 platform from the submitted profiles that varied by both vehicle type and road type. For the purposes of constructing the national default diurnal profiles, the EPA created individual profiles for each state (averaging over the counties within) to create a

[25] Note, the day of the week profiles (i.e., Monday vs Tuesday vs etc) are only from the VTRIS data. The MOVES CDBs only have weekday versus weekend profiles so they were not included in calculating a new national default day of the week profile.

single profile by state, vehicle type, road type, and the day (i.e., weekday versus Saturday versus Sunday). The source of the underlying profiles was either MOVES or VTRIS data (see Figure 3-21). The states individual profiles were averaged together to create a new default profile[26]. Figure 3-22 shows two new national default profiles for light duty gas vehicles (LDGV, SCC6 220121) and combination long-haul diesel trucks (HHDDV, SCC6 220262) on restricted urban roadways (interstates and freeways).

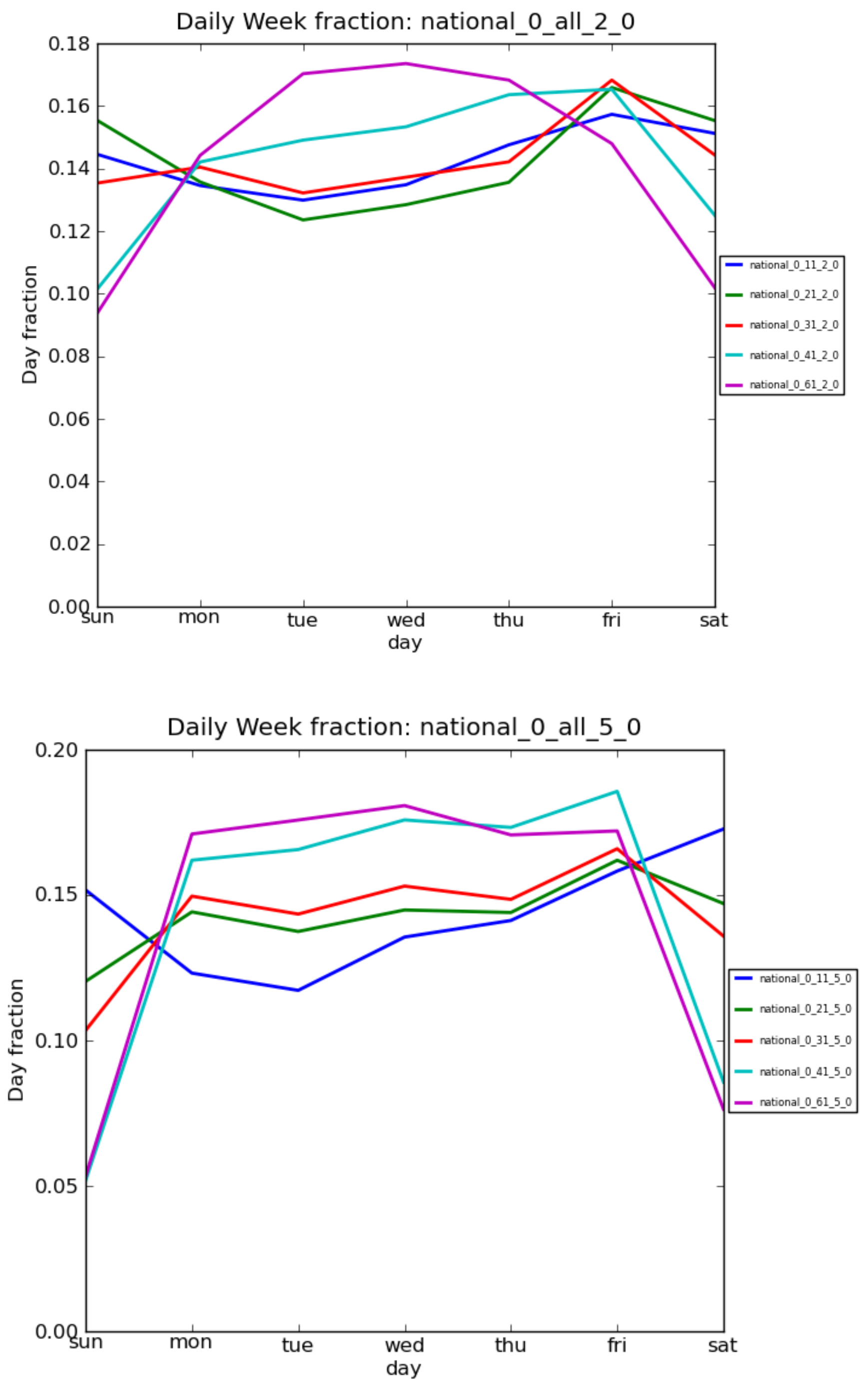
Figure 3-22. Updated national default profiles for LDGV vs. HHDDV, urban restricted



[26] Note that the states were weighted equally in the average independent of the size of the state or the variation in submitted county data.

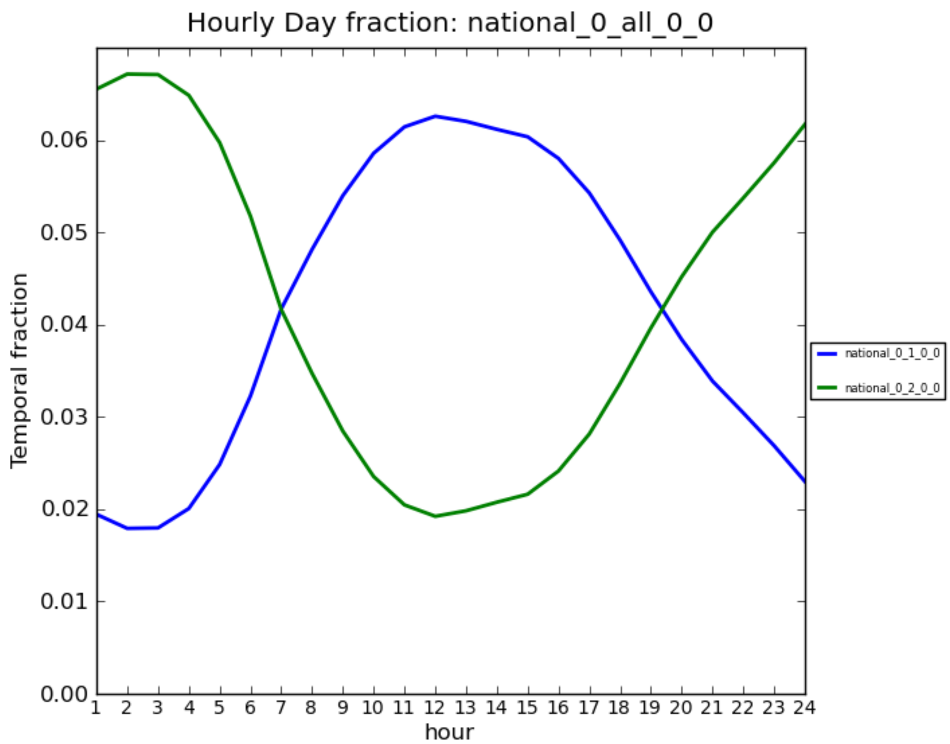
The blue lines of Figure Figure 3-22 indicate the weekday profile, the green the Saturday profile, and the red the Sunday profile. In comparison, the new default profiles for weekdays places more LDGV VMT (upper plot) in the rush hours while placing HHDDV VMT (lower plot) predominately in the middle of the day with a longer tail into the evening hours and early morning. In addition to creating diurnal profiles, the EPA developed day of week profiles using the VTRIS data. The creation of the state and national profiles was similar to the diurnal profiles (described above). Figure 3-23 shows a set of national default profiles for rural restricted roads (top plot) and urban unrestricted roads (lower plot). Each vehicle type is a different color on the plots.

Figure 3-23. Updated national default profiles for day of week



The EPA also developed a national profile for hoteling by averaging all the combination long-haul truck profiles on restricted roads (urban and rural) for weekdays to create a single national restricted profile (blue line in Figure 3-24). This was then inverted to create a profile for hoteling (green line in Figure 3-24). This single national profile was used for hoteling irrespective of location.

Figure 3-24. Combination long-haul truck restricted and hoteling profile



For California, CARB supplied diurnal profiles that varied by vehicle type, day of the week[27], 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's submittal to the 2011NEIv2, the temporalization of these emissions took into account both the state-specific VMT profiles and the SMOKE-MOVES process of incorporating meteorology. For more details on the adjustments to California's onroad emissions, see Section 2011 onroad mobile sources (onroad) and the 2011NEIv2 TSD.

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

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

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

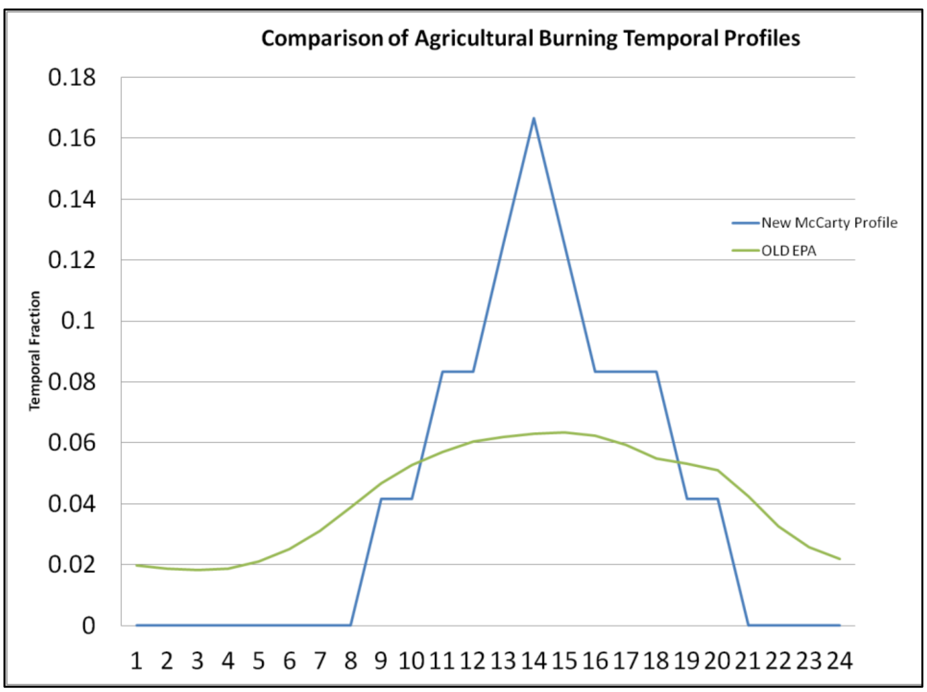
applied to remove all emissions for days where measureable rain occurs. Therefore, the afdust emissions vary day-to-day based on the precipitation and/or snow cover for that grid cell and day. Both the transport fraction and meteorological adjustments are based on the gridded resolution of the platform; therefore, somewhat different emissions will result from different grid resolutions. 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 and rail sectors, emissions are allocated with flat monthly and day of week profiles, and most emissions are also allocated with flat hourly profiles.

For the agfire sector, the emissions were allocated to months by adding up the available values for each day of the month. For all agricultural burning, the diurnal temporal profile used reflected the fact that burning occurs during the daylight hours - see Figure 3-25 (McCarty et al., 2009). This puts most of the emissions during the work day and suppresses the emissions during the middle of the night. A uniform profile for each day of the week was used for all agricultural burning emissions in all states, except for the following states that the EPA used state-specific day of week profiles: Arkansas, Iowa, Kansas, Louisiana, Minnesota, Missouri, Nebraska, Oklahoma, and Texas.

Figure 3-25. Agricultural burning diurnal temporal profile



Updates were made to temporal profiles for the ptnonipm sector in the 2011v6.2 platform based on comments and data review by EPA staff. Temporal profiles for small airports (i.e., non-commercial) were updated to eliminate emissions between 10pm and 6am due to a lack of tower operations. Industrial process that are not likely to shut down on Sundays such as those at cement plants were assigned to other more realistic profiles that included emissions on Sundays. This also affected emissions on holidays because Sunday emissions are also used on holidays.

For the ptfire sectors, the inventories are in the daily point fire format ORL PTDAY. The ptfire sector is used in the model evaluation case (2011ek) and in the future base case (2017ek). The 2007 and earlier platforms had additional regulatory cases that used averaged fires and temporally averaged EGU emissions, but the 2011 platform uses base year-specific (i.e., 2011) data for both cases.

For the nonroad sector, while the NEI only stores the annual totals, the modeling platform uses monthly inventories from output from NMIM. For California, a monthly inventory was created from CARB's annual inventory using EPA-estimated NMIM monthly results to compute monthly ratios by pollutant and SCC7 and these ratios were applied to the CARB inventory to create a monthly inventory.

Some cross reference updates for temporalization of the np_oilgas sector were made in the 2011v6.2 and 2011v6.3 platform to assign np_oilgas sources to 24 hour per day, 7 days a week based on comments received.

3.3.8 Time zone corrections

Various time zone corrections/updates were made to the 2011v6.3 platform, which affects the hourly temporalization of emissions. Table 3-18 lists the time zone corrections for U.S. counties. Almost the entire country of Mexico needed to be corrected. Most of country is Central time zone with DST, except for the six northwesternmost states. In the 2011v6.2 platform, most of Mexico was Central time without DST. The time zone corrections made to Canada are the following:

- Quebec: Seven census divisions moved from Atlantic Time to Eastern Time. Only one Quebec census division remains in Atlantic Time zone.
- Manitoba: Daylight Saving Time (DST) added. (Only affects entire province FIPS; individual census divisions were already correct.)
- Saskatchewan: now Central time without DST; was previously a mix of Central time and Mountain Time with DST.
- Peace River, BC: changed from Pacific Time with DST to Mountain Time without DST.
- NW Territories: moved from Pacific Time to Mountain Time. (Only affects entire province FIPS; individual census divisions were already correct.)

Table 3-18. Time zone corrections for US counties in 2011v6.3 platform

FIPS	State	County	2011eh	2011ek
ALL	Indiana	ALL	some with no daylight saving time implemented (DST)	all changed to implementing DST
20093	Kansas	Kearny Co	MT	CT
21087	Kentucky	Green Co	ET	CT
21225	Kentucky	Union Co	ET	CT
21233	Kentucky	Webster Co	ET	CT
38057	North Dakota	Mercer Co	MT	CT
38059	North Dakota	Morton Co	MT	CT
38065	North Dakota	Oliver Co	MT	CT
38085	North Dakota	Sioux Co	MT	CT
46075	South Dakota	Jones Co	MT	CT
46095	South Dakota	Mellette Co	MT	CT
46121	South Dakota	Todd Co	MT	CT

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 Emissions Modeling Overview, spatial allocation was performed for a national 12-km domain. To accomplish this, SMOKE used national 12-km spatial surrogates and a SMOKE area-to-point data file. For the U.S., the EPA updated surrogates to use circa 2010-2011 data wherever possible. For Mexico and Canada, updated spatial surrogates were used as described below. The U.S., Mexican, and Canadian 12-km surrogates cover the entire CONUS domain 12US1 shown in Figure 3-1.

The changes to spatial allocation in the 2011el platform were limited to the addition of SCCs from the MOVES-Mexico inventory to the spatial cross reference for Canada and Mexico. The 2011en platform update introduced a new set of Canadian spatial surrogates, a new shipping lanes surrogate for U.S. emissions, and a new population surrogate in Mexico. Otherwise, the exception of some updates to the spatial surrogate cross reference, the spatial surrogates for the U.S. and Mexico used in the 2011v6.3 platform are the same as the surrogates used for the 2011v6.2 platform (EPA, 2015b). The details regarding how the 2011v6.2 platform surrogates were created are available from ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/spatial_surrogates/ in the files *US_SpatialSurrogate_Workbook_v072115.xlsx* and *US_SpatialSurrogate_Documentation_v070115.pdf*, and *SurrogateTools_Scripts_2014.zip* available. The remainder of this subsection provides further detail on the origin of the data used for the spatial surrogates and the area-to-point data.

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 12-km grid cells used by the air quality model. Table 3-19 lists the codes and descriptions of the surrogates. Surrogate names and codes listed in *italics* are not directly assigned to any sources for the 2011v6.3 platform, 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.

Many surrogates use circa 2010-based data, including: 2010 census data at the block group level; 2010 American Community Survey Data for heating fuels; 2010 TIGER/Line data for railroads and roads; the 2006 National Land Cover Database; 2011 gas station and dry cleaner data; and the 2012 National Transportation Atlas Data for rail-lines, ports and navigable waterways. The surrogate for ports (820) was developed based on the shapefile Ports_2014NEI while the Shipping Lane surrogate (808) was based on the Shapefile CMV_2013_Vessel_Density_CONUS1km based on 2013 shipping data from http://marinecdastre.gov. This data set included shipping lane data in the Atlantic, Pacific, Great Lakes and the Gulf of Mexico. The creation of surrogates and shapefiles for the U.S. was generated via the Surrogate Tool. The tool and documentation for it is available at https://www.cmascenter.org/sa-tools/documentation/4.2/SurrogateToolUserGuide_4_2.pdf.

Table 3-19. U.S. Surrogates available for the 2011 modeling platform.

Code	Surrogate Description	Code	Surrogate Description
N/A	Area-to-point approach (see 3.3.1.2)	507	Heavy Light Construction Industrial Land
100	Population	510	Commercial plus Industrial
110	*Housing*	515	Commercial plus Institutional Land
120	*Urban Population*	520	Commercial plus Industrial plus Institutional
130	Rural Population	*525*	*Golf Courses + Institutional +Industrial + Commercial*
137	*Housing Change*	526	Residential Non-Institutional
140	Housing Change and Population	527	Single Family Residential
150	Residential Heating - Natural Gas	*530*	*Residential - High Density*
160	*Residential Heating – Wood*	535	Residential + Commercial + Industrial + Institutional + Government
165	0.5 Residential Heating - Wood plus 0.5 Low Intensity Residential	540	Retail Trade
170	Residential Heating - Distillate Oil	545	Personal Repair
180	Residential Heating – Coal	*550*	*Retail Trade plus Personal Repair*
190	Residential Heating - LP Gas	555	Professional/Technical plus General Government
200	Urban Primary Road Miles	560	Hospitals
205	Extended Idle Locations	*565*	*Medical Offices/Clinics*
210	Rural Primary Road Miles	*570*	*Heavy and High Tech Industrial*
220	*Urban Secondary Road Miles*	575	Light and High Tech Industrial
221	Urban Unrestricted Roads	580	Food, Drug, Chemical Industrial
230	*Rural Secondary Road Miles*	585	Metals and Minerals Industrial
231	Rural Unrestricted Roads	590	Heavy Industrial
240	Total Road Miles	595	Light Industrial
250	Urban Primary plus Rural Primary	*596*	*Industrial plus Institutional plus Hospitals*
255	*0.75 Total Roadway Miles plus 0.25 Population*	600	Gas Stations
256	Off-Network Short-Haul Trucks	650	Refineries and Tank Farms
257	Off-Network Long-Haul Trucks	675	Refineries and Tank Farms and Gas Stations
258	Intercity Bus Terminals	680	Oil & Gas Wells circa 2005 (replaced by newer surrogates in Table 3-21. Spatial Surrogates for Oil and Gas Sources)
259	Transit Bus Terminals	710	Airport Points
260	Total Railroad Miles	711	Airport Areas
261	NTAD Total Railroad Density	*720*	*Military Airports*
270	*Class 1 Railroad Miles*	*800*	*Marine Ports*

Code	Surrogate Description	Code	Surrogate Description
271	NTAD Class 1, 2, 3 Railroad Density	*801*	*NEI Ports*
280	Class 2 and 3 Railroad Miles	*802*	*NEI Shipping Lanes*
300	Low Intensity Residential	806	Offshore Shipping NEI NOx
310	Total Agriculture	*807*	*Navigable Waterway Miles*
312	Orchards/Vineyards	808	2013 Shipping Density
320	Forest Land	*810*	*Navigable Waterway Activity*
330	Strip Mines/Quarries	*812*	*Midwest Shipping Lanes*
340	*Land*	820	Ports NEI2014 Activity
350	Water	850	Golf Courses
400	Rural Land Area	860	Mines
500	Commercial Land	870	Wastewater Treatment Facilities
505	Industrial Land	880	Drycleaners
506	Education	890	Commercial Timber

For the onroad sector, the on-network (RPD) emissions were spatially allocated to roadways. The refueling emissions were spatially allocated to gas station locations (surrogate 600). On-network (i.e., on-roadway) mobile source emissions were assigned to the following surrogates: rural restricted access to rural primary road miles (210); rural unrestricted access to 231; urban restricted access to urban primary road miles (200); and urban unrestricted access to 221. Off-network (RPP and RPV) emissions were spatially allocated according to the mapping in Table 3-20. Starting with the 2011v6.2 platform, emissions from the extended (i.e., overnight) idling of trucks were assigned to a new surrogate 205 that is based on locations of overnight truck parking spaces.

Table 3-20. Off-Network Mobile Source Surrogates

Source type	Source Type name	Surrogate ID
11	Motorcycle	535
21	Passenger Car	535
31	Passenger Truck	535
32	Light Commercial Truck	510
41	Intercity Bus	258
42	Transit Bus	259
43	School Bus	506
51	Refuse Truck	507
52	Single Unit Short-haul Truck	256
53	Single Unit Long-haul Truck	257
54	Motor Home	526
61	Combination Short-haul Truck	256
62	Combination Long-haul Truck	257

For the oil and gas sources in the np_oilgas sector, the spatial surrogates were updated to those shown in Table **3-21** using 2011 data consistent with what was used to develop the 2011NEI nonpoint oil and gas emissions. Note that the “Oil & Gas Wells, IHS Energy, Inc. and USGS” (680) is older and based on circa-2005 data. These surrogates were based on the same GIS data of well locations and related attributes as was used to develop the 2011NEIv2 data for the oil and gas sector. The data sources include Drilling Info (DI) Desktop's HPDI database (Drilling Info, 2012) aggregated to grid cell levels, along with data from Oil and Gas Commission (OGC) websites. Well completion data from HPDI was supplemented by implementing the methodology for counting oil and gas well completions developed for the U.S. National Greenhouse Gas Inventory. Under that methodology, both completion date and date of first production from HPDI were used to identify wells completed during 2011. In total, over 1.08 million unique well locations were compiled from the various data sources. The well locations cover 33 states and 1,193 counties (ERG, 2014b).

Table 3-21. Spatial Surrogates for Oil and Gas Sources

Surrogate Code	Surrogate Description
681	Spud count - Oil Wells
682	Spud count - Horizontally-drilled wells
683	Produced Water at all wells
684	Completions at Gas and CBM Wells
685	Completions at Oil Wells
686	Completions at all wells
687	Feet drilled at all wells
688	Spud count - Gas and CBM Wells
689	Gas production at all wells
692	Spud count - All Wells
693	Well count - all wells
694	Oil production at oil wells
695	Well count - oil wells
697	Oil production at Gas and CBM Wells
698	Well counts - Gas and CBM Wells

Some spatial surrogate cross reference updates were made between the 2011v6.2 platform and the 2011v6.3 platform aside from the reworking of the onroad mobile source surrogates described above. These updates included the following:

- Nonroad SCCs using spatial surrogate 525 (50 percent commercial + industrial + institutional, 50 percent golf courses) were changed to 520 (100 percent commercial + industrial + institutional). The golf course surrogate 850, upon which 525 is partially based, is incomplete and subject to hot spots;
- Some nonroad SCCs for commercial equipment in New York County had assignments updated to surrogate 340;
- Commercial lawn and garden equipment was updated to use surrogate 520; and
- Some county-specific assignments for residential wood combustion (RWC) were updated to use surrogate 300.

For the 2011en update to the 2011v6.3 platform, the CMV underway emissions were changed to use surrogate 808. RWC fireplaces in all counties, and other RWC emissions in select counties, were changed to use surrogate 300.

Not all of the available surrogates are used to spatially allocate sources in the modeling platform; that is, some surrogates shown in Table 3-19 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 3-22 shows the CAP emissions (i.e., ammonia (NH_3), NOx, $PM_{2.5}$, SO_2, and VOC) by sector, with rows for each sector listed in order of most emissions to least CAP emissions.

Table 3-22. Selected 2011en CAP emissions by sector for U.S. Surrogates*

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
afdust	130	Rural Population	0	0	1,089,422	0	0
afdust	140	Housing Change and Population	0	0	159,485	0	0
afdust	240	Total Road Miles	0	0	286,188	0	0
afdust	310	Total Agriculture	0	0	895,786	0	0
afdust	330	Strip Mines/Quarries	0	0	58,959	0	0
afdust	400	Rural Land Area	0	0	1	0	0
ag	310	Total Agriculture	3,502,246	0	0	0	0
agfire	310	Total Agriculture	3,287	45,594	100,174	17,001	79,615
agfire	312	Orchards/Vineyards	27	432	1,082	753	799
agfire	320	Forest Land	7	8	121	0	124
cmv_c1c2	808	2013 Shipping Density	332	510,868	16,326	7,352	12,309
cmv_c1c2	820	Ports NEI2011 NOx	23	61,823	2,072	2,354	1,883
nonpt	100	Population	4,137	0	0	0	1,196,465
nonpt	140	Housing Change and Population	3	23,423	65,897	29	134,887
nonpt	150	Residential Heating - Natural Gas	40,775	217,560	4,785	1,443	12,660
nonpt	170	Residential Heating - Distillate Oil	2,045	40,842	4,523	88,432	1,394
nonpt	180	Residential Heating - Coal	247	1,033	605	7,931	1,233
nonpt	190	Residential Heating - LP Gas	136	38,705	224	705	1,432
nonpt	240	Total Road Miles	0	27	602	0	32,152
nonpt	250	Urban Primary plus Rural Primary	0	0	0	0	102,207
nonpt	260	Total Railroad Miles	0	0	0	0	2,195
nonpt	300	Low Intensity Residential	3,847	18,334	90,706	3,048	40,003
nonpt	310	Total Agriculture	0	0	614	0	363,385
nonpt	312	Orchards/Vineyards	0	441	117	1,806	262
nonpt	320	Forest Land	0	85	287	0	97
nonpt	330	Strip Mines/Quarries	0	4	0	0	48
nonpt	400	Rural Land Area	2,855	0	0	0	0
nonpt	500	Commercial Land	2,367	2	85,404	585	26,183
nonpt	505	Industrial Land	35,360	195,282	124,150	112,016	114,391
nonpt	510	Commercial plus Industrial	4	178	27	109	224,110
nonpt	515	Commercial plus Institutional Land	1,408	177,903	18,637	58,798	21,710
nonpt	520	Commercial plus Industrial plus Institutional	0	0	0	0	14,965
nonpt	527	Single Family Residential	0	0	0	0	153,528

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
nonpt	535	Residential + Commercial + Industrial + Institutional + Government	23	366	1,283	0	327,986
nonpt	540	Retail Trade (COM1)	0	0	0	0	1,371
nonpt	545	Personal Repair (COM3)	0	0	93	0	60,289
nonpt	555	Professional/Technical (COM4) plus General Government (GOV1)	0	0	0	0	2,865
nonpt	560	Hospital (COM6)	0	0	0	0	10
nonpt	575	Light and High Tech Industrial (IND2 + IND5)	0	0	0	0	2,538
nonpt	580	Food, Drug, Chemical Industrial (IND3)	0	610	313	171	10,535
nonpt	585	Metals and Minerals Industrial (IND4)	0	23	140	8	443
nonpt	590	Heavy Industrial (IND1)	10	4,373	5,419	1,131	138,575
nonpt	595	Light Industrial (IND2)	0	1	244	0	79,169
nonpt	600	Gas Stations	0	0	0	0	416,448
nonpt	650	Refineries and Tank Farms	0	0	0	0	129,221
nonpt	675	Refineries and Tank Farms and Gas Stations	0	0	0	0	1,203
nonpt	711	Airport Areas	0	0	0	0	1,956
nonpt	801	Port Areas	0	0	0	0	12,469
nonpt	870	Wastewater Treatment Facilities	1,003	0	0	0	4,671
nonpt	880	Drycleaners	0	0	0	0	7,053
nonroad	100	Population	40	39,475	2,824	85	5,030
nonroad	140	Housing Change and Population	554	537,250	45,058	1,255	78,526
nonroad	261	NTAD Total Railroad Density	2	2,673	310	5	568
nonroad	300	Low Intensity Residential	106	26,637	4,324	138	202,928
nonroad	310	Total Agriculture	481	488,224	39,037	910	57,473
nonroad	350	Water	213	143,096	12,395	337	614,637
nonroad	400	Rural Land Area	157	25,658	16,711	194	620,786
nonroad	505	Industrial Land	452	146,871	5,809	411	32,978
nonroad	510	Commercial plus Industrial	382	131,572	9,888	348	139,291
nonroad	520	Commercial plus Industrial plus Institutional	205	70,541	16,361	288	255,836
nonroad	850	Golf Courses	12	2,394	112	17	7,092
nonroad	860	Mines	2	2,931	341	5	594
nonroad	890	Commercial Timber	19	12,979	1,486	38	8,680
np_oilgas	400	Rural Land Area	0	0	0	0	50
np_oilgas	680	Oil and Gas Wells	0	10	0	0	55
np_oilgas	681	Spud count - Oil Wells	0	0	0	0	6,700
np_oilgas	682	Spud count - Horizontally-drilled wells	0	5,526	208	9	349
np_oilgas	683	Produced Water at all wells	0	0	0	0	44,772
np_oilgas	684	Completions at Gas and CBM Wells	0	2,579	46	434	11,706
np_oilgas	685	Completions at Oil Wells	0	360	11	376	28,194
np_oilgas	686	Completions at all wells	0	45,044	1,742	106	101,803
np_oilgas	687	Feet drilled at all wells	0	44,820	1,449	119	9,714
np_oilgas	688	Spud count - Gas and CBM Wells	0	0	0	0	11,322
np_oilgas	689	Gas production at all wells	0	39,184	2,318	224	64,828

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
np_oilgas	692	Spud count - all wells	0	30,138	445	502	4,598
np_oilgas	693	Well count - all wells	0	23,437	436	93	48,205
np_oilgas	694	Oil production at oil wells	0	2,332	0	12,602	729,483
np_oilgas	695	Well count - oil wells	0	96,244	3,067	88	431,306
np_oilgas	697	Oil production at gas and CBM wells	0	3,579	183	34	465,478
np_oilgas	698	Well count - gas and CBM wells	0	373,808	6,428	2,644	525,201
onroad	200	Urban Primary Road Miles	27,650	972,477	36,555	5,698	166,352
onroad	205	Extended Idle Locations	792	287,139	6,085	102	68,756
onroad	210	Rural Primary Road Miles	12,380	812,492	24,653	2,665	81,013
onroad	221	Urban Unrestricted Roads	49,327	1,574,451	64,354	12,078	429,908
onroad	231	Rural Unrestricted Roads	30,711	1,271,368	42,148	6,577	232,468
onroad	256	Off-Network Short-Haul Trucks	0	13,769	305	13	17,456
onroad	257	Off-Network Long-Haul Trucks	0	458	38	2	1,421
onroad	258	Intercity Bus Terminals	0	168	3	0	39
onroad	259	Transit Bus Terminals	0	43	4	0	123
onroad	506	Education	0	633	31	1	1,037
onroad	507	Heavy Light Construction Industrial Land	0	558	10	0	157
onroad	510	Commercial plus Industrial	0	121,163	2,001	131	195,186
onroad	526	Residential - Non-Institutional	0	658	18	1	2,122
onroad	535	Residential + Commercial + Industrial + Institutional + Government	0	652,562	12,720	927	1,319,131
onroad	600	Gas Stations	0	0	0	0	198,012
rail	261	NTAD Total Railroad Density	2	16,536	379	260	925
rail	271	NTAD Class 1 2 3 Railroad Density	332	732,956	22,636	7,390	38,304
rail	280	Class 2 and 3 Railroad Miles	13	41,886	948	287	1,622
rwc	165	0.5 Residential Heating - Wood plus 0.5 Low Intensity Residential	15,162	27,530	318,442	7,900	385,325
rwc	300	Low Intensity Residential	4,520	6,883	62,481	1,049	56,858

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

The surrogates for Canada to spatially allocate the 2013 Canadian emissions have been updated in the 2011en platform. The spatial surrogate data came from Environment Canada, along with cross references. The surrogates they provided were outputs from the Surrogate Tool (previously referenced). The Canadian surrogates used for this platform are listed in Table 3-23. Surrogates for Mexico are circa 1999 and 2000 and were based on data obtained from the Sistema Municpal 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 3-24. The emissions in this table are from the othar, othon, and othafdust sectors.

Table 3-23. Canadian Spatial Surrogates based on 2013 Inventory

Code	Canadian Surrogate Description	Code	Description
100	Population	941	PAVED ROADS
101	total dwelling	942	UNPAVED ROADS
106	ALL_INDUST	945	Commercial Marine Vessels
113	Forestry and logging	950	Combination of Forest and Dwelling
115	Agriculture and forestry activities	955	UNPAVED_ROADS_AND_TRAILS
200	Urban Primary Road Miles	960	TOTBEEF
210	Rural Primary Road Miles	965	TOTBEEF_CD
212	Mining except oil and gas	966	TOTPOUL_CD
220	Urban Secondary Road Miles	967	TOTSWIN_CD
221	Total Mining	968	TOTFERT_CD
222	Utilities	970	TOTPOUL
230	Rural Secondary Road Miles	980	TOTSWIN
240	Total Road Miles	990	TOTFERT
308	Food manufacturing	996	urban_area
321	Wood product manufacturing	1211	Oil and Gas Extraction
323	Printing and related support activities	1212	OilSands
324	Petroleum and coal products manufacturing	1251	OFFR_TOTFERT
326	Plastics and rubber products manufacturing	1252	OFFR_MINES
327	Non-metallic mineral product manufacturing	1253	OFFR Other Construction not Urban
331	Primary Metal Manufacturing	1254	OFFR Commercial Services
412	Petroleum product wholesaler-distributors	1255	OFFR Oil Sands Mines
416	Building material and supplies wholesaler-distributors	1256	OFFR Wood industries CANVEC
448	clothing and clothing accessories stores	1257	OFFR Unpaved Roads Rural
562	Waste management and remediation services	1258	OFFR_Utilities
921	Commercial Fuel Combustion	1259	OFFR total dwelling
923	TOTAL INSTITUTIONAL AND GOVERNEMNT	1260	OFFR_water
924	Primary Industry	1261	OFFR_ALL_INDUST
925	Manufacturing and Assembly	1262	OFFR Oil and Gas Extraction
926	Distribtution and Retail (no petroleum)	1263	OFFR_ALLROADS
927	Commercial Services	1264	OFFR_OTHERJET
931	OTHERJET	1265	OFFR_CANRAIL
932	CANRAIL		

Table 3-24. CAPs Allocated to Mexican and Canadian Spatial Surrogates for 2011en

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	PM_{2_5}	SO_2	VOC
11	MEX 2015 Population	22,095	94,828	3,784	405	121,164
14	MEX Residential Heating - Wood	0	1,010	12,952	155	89,053

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	PM_{2_5}	SO_2	VOC
16	MEX Residential Heating - Distillate Oil	0	11	0	3	0
20	MEX Residential Heating - LP Gas	0	5,042	152	0	86
22	MEX Total Road Miles	2,154	306,924	8,198	4,305	68,105
24	MEX Total Railroads Miles	0	18,710	418	164	729
26	MEX Total Agriculture	146,737	105,222	22,250	5,106	8,400
32	MEX Commercial Land	0	61	1,343	0	19,436
34	MEX Industrial Land	3	1,055	1,626	0	98,577
36	MEX Commercial plus Industrial Land	0	1,559	26	4	83,144
38	MEX Commercial plus Institutional Land	2	1,427	64	3	42
40	MEX Residential (RES1-4)+Comercial+Industrial+Institutional+Government	0	4	9	0	63,022
42	MEX Personal Repair (COM3)	0	0	0	0	4,637
44	MEX Airports Area	0	2,521	68	319	796
46	MEX Marine Ports	0	8,291	526	4,150	84
50	MEX Mobile sources - Border Crossing - Mexico	4	136	1	2	252
100	CAN Population	593	50	585	11	263
101	CAN total dwelling	272	25,281	1,881	2,447	113,352
106	CAN ALL_INDUST	0	0	6,828	0	70
113	CAN Forestry and logging	268	1,693	0	77	5,056
115	CAN Agriculture and forestry activities	15	180	905	4	504
200	CAN Urban Primary Road Miles	1,460	65,668	2,918	261	8,929
210	CAN Rural Primary Road Miles	572	39,595	1,597	104	3,819
212	CAN Mining except oil and gas	0	0	2,108	0	0
220	CAN Urban Secondary Road Miles	2,713	98,357	5,484	553	21,628
221	CAN Total Mining	0	0	34,755	0	0
222	CAN Utilities	56	8,298	31,963	2,969	175
230	CAN Rural Secondary Road Miles	1,551	70,821	3,091	286	10,313
240	CAN Total Road Miles	31	58,110	2,036	66	93,692
308	CAN Food manufacturing	0	0	8,783	0	5,563
321	CAN Wood product manufacturing	182	1,613	0	85	5,802
323	CAN Printing and related support activities	0	0	0	0	10,739
324	CAN Petroleum and coal products manufacturing	0	529	645	238	2,268
326	CAN Plastics and rubber products manufacturing	0	0	0	0	16,066
327	CAN Non-metallic mineral product manufacturing	0	0	5,213	0	0
331	CAN Primary Metal Manufacturing	0	140	5,183	45	72
412	CAN Petroleum product wholesaler-distributors	0	0	0	0	29,688
448	CAN clothing and clothing accessories stores	0	0	0	0	81
562	CAN Waste management and remediation services	182	1,384	1,755	2,166	13,644
921	CAN Commercial Fuel Combustion	132	18,212	1,741	1,814	856
923	CAN TOTAL INSTITUTIONAL AND GOVERNEMNT	0	0	0	0	10,964
924	CAN Primary Industry	0	0	0	0	25,806
925	CAN Manufacturing and Assembly	0	0	0	0	56,437
926	CAN Distribution and Retail (no petroleum)	0	0	0	0	5,641
927	CAN Commercial Services	0	0	0	0	24,386
932	CAN CANRAIL	30	66,583	1,550	240	3,317

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	PM $_{2\_5}$	SO_2	VOC
941	CAN PAVED ROADS	0	0	211,630	0	0
945	CAN Commercial Marine Vessels	77	63,283	2,338	14,649	3,598
950	CAN Combination of Forest and Dwelling	1,178	13,084	107,784	1,869	152,929
955	CAN UNPAVED_ROADS_AND_TRAILS	0	0	254,039	0	0
960	CAN TOTBEEF	0	0	791	0	164,199
965	CAN TOTBEEF_CD	177,624	0	0	0	0
966	CAN TOTPOUL_CD	20,316	0	0	0	0
967	CAN TOTSWIN_CD	59,387	0	0	0	0
968	CAN TOTFERT_CD	77,861	0	0	0	0
970	CAN TOTPOUL	0	0	156	0	209
980	CAN TOTSWIN	0	0	655	0	2,251
990	CAN TOTFERT	0	3,281	238,181	6,685	124
996	CAN urban_area	0	0	778	0	0
1211	CAN Oil and Gas Extraction	0	29	54,361	50	444
1212	CAN OilSands	0	0	0	0	0
1251	CAN OFFR_TOTFERT	71	77,251	5,715	52	7,079
1252	CAN OFFR_MINES	30	29,069	2,413	22	2,947
1253	CAN OFFR Other Construction not Urban	20	18,121	2,927	15	7,165
1254	CAN OFFR Commercial Services	28	14,606	1,803	23	18,293
1255	CAN OFFR Oil Sands Mines	0	0	0	0	0
1256	CAN OFFR Wood industries CANVEC	11	9,857	932	8	1,619
1257	CAN OFFR Unpaved Roads Rural	22	6,773	1,157	19	44,089
1258	CAN OFFR_Utilities	14	7,109	447	12	8,518
1259	CAN OFFR total dwelling	14	4,372	1,130	12	27,729
1260	CAN OFFR_water	2	603	93	3	5,663
1261	CAN OFFR_ALL_INDUST	3	3,671	238	3	749
1262	CAN OFFR Oil and Gas Extraction	0	509	31	0	101
1263	CAN OFFR_ALLROADS	1	931	65	1	399
1264	CAN OFFR_OTHERJET	1	781	65	1	66
1265	CAN OFFR_CANRAIL	0	65	6	0	11

4 Development of 2023 Base-Case Emissions

The emission inventories for the future year of 2023 have been developed using projection methods that are specific to the type of emission source. Future emissions are projected from the 2011 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 and fires. 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.

Emissions inventories for neighboring countries used in our modeling are included in this platform, specifically 2011 and 2023 emissions inventories for Mexico, and 2013 and 2025 emissions inventories for Canada. The meteorological data used to create and temporalize emissions for the future year cases is held constant and represents the year 2011. With the exception of speciation profiles for mobile sources and temporal profiles for EGUs, the same ancillary data files are used to prepare the future year emissions inventories for air quality modeling as were used to prepare the 2011 base year inventories.

The approach for developing the EGU emissions **for 2023en** is described in Section 4.1. For 2023el, emission projections for EGUs were developed using IPM version 5.16 and are reflected in an air quality modeling-ready flat file taken from the EPA Base Case v.5.16. The NEEDS database is an important input to IPM in that contains the generation unit records used for the model plants that represent existing and planned/committed units in EPA modeling applications of IPM. NEEDS includes basic geographic, operating, air emissions, and other data on these generating units and has been updated for the EPA's version 5.16 power sector modeling platform. The EGU emission projections in the flat file format, the corresponding NEEDS database, and user guides and documentation are available with the information for the EPA's Power Sector Modeling Platform v.5.16 available from https://www.epa.gov/airmarkets/clean-air-markets-power-sector-modeling. The projected EGU emissions for 2023el included the Final Mercury and Air Toxics (MATS) rule announced on December 21, 2011, the Cross-State Air Pollution Rule (CSAPR) issued July 6, 2011, the CSAPR Update Rule issued October 26, 2016 and the Clean Power Plan (CPP), while the 2023en emissions include the other rules but do not include the CPP.

To project future emissions for onroad and nonroad mobile sources, the EPA used MOVES2014a and NMIM, respectively. The EPA obtained future year projected emissions for these sectors by running the MOVES and NMIM models using year-specific information about fuel mixtures, activity data, and the impacts of national and state-level rules and control programs. For this platform, the mobile source emissions for 2023 were generated by using year 2023 activity data coupled with emission factors for a MOVES run for the year 2023.

For non-EGU point and nonpoint sources, projections of 2023 emissions were developed by starting with the 2011 emissions inventories and applying adjustments that represent the impact of national, state, and local rules coming into effect in the intervening years, along with the impacts of planned shutdowns, the construction of new plants, specific information provided by states, and specific legal obligations resolving alleged environmental violations, such as consent decrees. Changes in activity are considered for sectors such as oil and gas, residential wood combustion, cement kilns, livestock, aircraft, commercial marine vessels and locomotives. Efforts were made to include some regional haze and state-reported local controls as part of a larger effort to include more local control information on stationary non-EGU sources.

The Mid-Atlantic Regional Air Management Association (MARAMA) provided projection and control data for year 2023 for most non-point and point sectors of the year 2011 inventory. The sectors affected are afdust, ag, cmv, nonpt, np_oilgas, pt_oilgas, ptnonipm, rail, rwc, and also portable fuel containers a subsector of nonpt. These MARAMA data consisted of projection and control packets used by EPA's Control Strategy Tool (CoST) and SMOKE to develop emissions for the following states: Virginia, North Carolina, New Hampshire, New York, Pennsylvania, New Jersey, West Virginia, Connecticut, Delaware, Vermont, Maine, Rhode Island, Maryland, Massachusetts, and District of Columbia. These MARAMA packets will be made available as part of the Data Files and Summaries found at https://www.epa.gov/air-emissions-modeling/2011-version-63-platform. They were developed using methods similar to those documented in the TSD Inventory Growth and Control Factors based on EPA 2011NEIv1 Emissions Modeling Platform (SRA, 2014)

The following bullets summarize the projection methods used for sources in the various sectors, while additional details and data sources are given in the following subsections and in Table 4-1.

- EGU sector (ptegu): 2023en included EGU emissions developed using an engineering analysis approach describe in Section 4.1 and did not include CPP, while 2023el used unit-specific estimates from IPM version 5.16, including CPP, CSAPR Update, CSAPR, MATS rule, Regional Haze rule, and the Cooling Water Intakes Rule.
- Non-IPM sector (ptnonipm): Closures, projection factors and percent reductions reflect comments received from the notices of data availability for the 2011, 2017, 2018, and 2023 emissions modeling platforms including closure updates from states in summer 2017, along with emission reductions due to national and local rules, control programs, plant closures, consent decrees and settlements. Projection for corn ethanol and biodiesel plants, refineries and upstream impacts take into account Annual Energy Outlook (AEO) fuel volume projections. Airport-specific terminal area forecast (TAF) data were used for aircraft to account for projected changes in landing/takeoff activity. The year represented for this sector is 2025, except that MARAMA factors for the year 2023 were used, where applicable.
- Point and nonpoint oil and gas sectors (pt_oilgas and np_oilgas): In 2023en, state projection factors were generated using historical oil and gas production data available for 2011 to 2015 from EIA and information from AEO 2017 projections to year 2023. For 2023el, regional projection factors were used (EPA, 2016b). Co-benefits of stationary engines CAP-cobenefit reductions (RICE NESHAP) and controls from New Source Performance Standards (NSPS) are reflected for select source categories. MARAMA factors for the year 2023 were used where applicable.
- Biogenic (beis): 2011 emissions are used for all future-year scenarios and are computed with the same "11g" meteorology as is used for the air quality modeling. The 2011en case included minor corrections to the BELD4.1 landuse that used as input into the BEIS3.61 modeling system.
- Fires sectors (ptfire, agfire): No growth or control – 2011 estimates are used directly.
- Agricultural sector (ag): Year 2023 projection factors for livestock estimates based on expected changes in animal population from 2005 USDA data, updated according to EPA experts in July 2012.
- Area fugitive dust sector (afdust): For livestock PM emissions, projection factors for dust categories related to livestock estimates based on expected changes in animal population. For unpaved and paved road dust, county-level VMT projections to 2023 were considered.
- Remaining Nonpoint sector (nonpt): Projection factors and percent reductions reflect comments received from the notices of data availability for the 2011, 2017, 2018, and 2023 emissions modeling platforms, along with emission reductions due to national and local rules/control programs. PFC projection factors reflecting impact of the final Mobile Source Air Toxics (MSAT2) rule. Upstream impacts from AEO fuel volume, including cellulosic ethanol plants, are reflected. The year represented for this sector is

2025, except that MARAMA factors for the year 2023 were used, where applicable. Changes in the 2023en case include the following:

- o The New York VOC change from 2011en case described in Section 2.2 was carried through to 2023en.
- o A new Boiler MACT packet for North Carolina was implemented: NCDAQ_CONTROL_2011v6_2_2023_BoilerMACT_POINT_051917.xlsx (This replaces MARAMA Boiler MACT controls in North Carolina used in 2023el)
- o The "nonpoint offsets" MARAMA inventory included in 2023el case were not used in the 2023en case as they were deemed inappropriate for national ozone transport modeling.

- Residential Wood Combustion (rwc): Year 2023 projection factors reflect assumed growth of wood burning appliances based on sales data, equipment replacement rates and change outs. These changes include the 2-stage NSPS for Residential Wood Heaters, resulting in growth in lower-emitting stoves and a reduction in higher emitting stoves.
- Locomotive, and non-Category 3 commercial marine sector (cmv and rail): Year 2023 projection factors for Category 1 and Category 2 commercial marine and locomotives reflect final locomotive-marine controls.
- Category 3 commercial marine vessel (cmv): Base-year 2011 emissions grown and controlled to 2023, incorporating controls based on Emissions Control Area (ECA) and International Marine Organization (IMO) global NOx and SO_2 controls.
- Nonroad mobile sector (nonroad): Other than for California and Texas, this sector uses data from a run of NMIM that utilized NONROAD2008a, using future-year equipment population estimates and control programs to 2023. The inputs were either state-supplied as part of the 2011NEIv2 process or using national level inputs, with only minor updates for 2011NEIv2. Final controls from the final locomotive-marine and small spark ignition rules are included. California data for 2023 were provided by the California Air Resources Board (CARB). For Texas, the Texas Commission on Environmental Quality (TCEQ) data were projected from 2011 to 2023 using trends based on NMIM data. For the 2023en case, temporal profile updates described in Section 3.3.2 for the 2011en case were carried forward for year 2023 modeling.
- Onroad mobile (onroad): MOVES2014a-based emissions factors for year 2023 were developed using the same representative counties, state-supplied data, meteorology, and procedures as were used to produce the 2011 emission factors. See section 4.3.1.1 for details about future year activity data used in generating emissions estimates.
- Onroad emissions data for California were provided by CARB.
- Other point (othpt), nonpoint/nonroad (othar, othafdust), onroad (othon): For Canada, year 2025inventories acquired from Environment Canada were used in the 2023en case for all of these sectors. In the 2023el case, the Canadian emissions were projected from the 2010 Environment Canada inventories for the othon and for the nonroad part of the othar sectors using projection factors derived from U.S. emissions changes from 2011 to 2023 by SCC and pollutant. In the othpt sector for the 2023el case, the Canadian point sources were modified by removing any remaining EGU facilities using coal. For Mexico, the othon inventory data in both cases were based on a 2023 run of MOVES-Mexico, while othar and othpt inventory data were interpolated to 2023 between 2018 and 2025. Offshore oil platform emissions were held constant at 2011 levels.

Table 4-1 summarizes the growth and control assumptions by source type that were used to create the U.S. 2023 base-case emissions from the base year inventories. The control, closures and projection packets (i.e., data sets) used to create the 2023 future year base-case scenario inventories from the 2011 base case are provided on the EMCH website and are discussed in more detail in the sections listed in Table 4-1. These packets were processed through CoST to create future year emission inventories. CoST is described here: https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-analysis-modelstools-air-pollution and discussed in context to this emissions modeling platform in Section 4.2.1. The last column in Table 4-1 indicates the order of the CoST strategy used for the source/packet type. For some sectors (e.g., ptnonipm), multiple CoST strategies are needed to produce the future year inventory because the same source category may be subject to multiple projection or control packets. For example, the "Loco-marine" projection factors are applied in a second control strategy for the ptnonipm sector, while for the cmv and rail sectors, these same projection factors can be applied in the first (and only) control strategy. Thus, in Table 4-1, packets with a "1" in the CoST strategy column are applied in the first strategy, while packets with a "2" in the CoST strategy column are applied in a second strategy that is run on an intermediate inventory output from the first strategy.

The remainder of this section is organized by broad NEI sectors with further stratification by the types of packets (e.g., projection, control, closure packets) and whether emissions are projected via a stand-alone model (e.g., EGUs use the IPM model and onroad mobile uses MOVES), using CoST, or by other mechanisms. The EGU projections are discussed in Section 4.1. Non-EGU point and nonpoint sector projections (including all commercial marine vessels, locomotives and aircraft) are described in Section 4.2, along with some background on CoST. Onroad and nonroad mobile projections are discussed in Section 4.3. Finally, projections for all "other" sources, primarily outside the U.S., are described in Section 4.44. Section 5 contains summaries of the 2011 and 2023 emissions the emissions changes between the years for emissions both within and outside of the U.S.

Table 4-1. Growth and control methodologies used to create future year emissions inventories

Description of growth, control, closure data, or, new inventory	Sector(s)	Packet Type	CAPs impacted	Section(s)	CoST Strategy
Non-EGU Point (ptnonipm and pt_oilgas sectors) Growth and Control Assumptions					
Facility, unit and stack closures, primarily from the Emissions Inventory System (EIS)	ptnonipm, pt_oilgas	CLOSURE	All	4.2.2	1
"Loco-marine rule": Growth and control to years 2023 from Locomotives and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder: March, 2008	ptnonipm, cmv, rail	PROJECTION	All	4.2.3.3	2, 1
Upstream RFS2/EISA/LDGHG impacts on gas distribution, pipelines and refineries to future years	ptnonipm, pt_oilgas, nonpt	PROJECTION	All	4.2.3.4	2
AEO-based growth for industrial sources, including oil and gas regional projections	ptnonipm, pt_oilgas, nonpt, np_oilgas	PROJECTION	All	4.2.3.5	1
Aircraft growth via Itinerant (ITN) operations at airports	ptnonipm	PROJECTION	All	4.2.3.6	1
Corn Ethanol plants adjusted via AEO volume projections to 2025	ptnonipm	PROJECTION	All	4.2.3.8	1
NESHAP: Portland Cement projects. These results are from model runs associated with the NESHAP and NSPS analysis of August, 2013 and include closures and growth.	ptnonipm, nonpt	PROJECTION & new inventories for new kilns	All	4.2.3.7 & 4.2.5.4	1 & n/a
NESHAP: RICE (reciprocating internal combustion engines) with reconsideration amendments	ptnonipm, pt_oilgas, nonpt, np_oilgas	CONTROL	CO, NO_X, PM, SO_2, VOC	4.2.4.2	1
NSPS: oil and gas	pt_oilgas, np_oilgas	CONTROL	VOC	4.2.4.1	1

Description of growth, control, closure data, or, new inventory	Sector(s)	Packet Type	CAPs impacted	Section(s)	CoST Strategy
NSPS: RICE	ptnonipm, pt_oilgas, nonpt, np_oilgas	CONTROL	CO, NO_X, VOC	4.2.4.3	2
NSPS: Gas turbines	ptnonipm, pt_oilgas	CONTROL	NO_X	4.2.4.6	1
NSPS: Process heaters	ptnonipm, pt_oilgas	CONTROL	NO_X	4.2.4.7	1
Industrial/Commercial/Institutional Boiler MACT with Reconsideration Amendments + local programs	nonpt, ptnonipm, pt_oilgas	CONTROL	CO, NO_X, PM, SO_2, VOC	4.2.4.4	1
State fuel sulfur content rules for fuel oil – via 2018 NODA comments, effective only in most northeast states	nonpt, ptnonipm, pt_oilgas	CONTROL	SO_2	4.2.4.5	1
State comments: from previous platforms (including consent decrees) and NODAs	nonpt, ptnonipm, pt_oilgas	PROJECTION & CONTROL	All	4.2.3.5, 4.2.4.11	1
Commercial and Industrial Solid Waste Incineration (CISWI) revised NSPS	ptnonipm	CONTROL	SO2	4.2.4.9	1
Arizona Regional haze controls	ptnonipm	CONTROL	NO_X,SO_2	4.2.4.8	1
New biodiesel plants for year 2018	ptnonipm	new inventory	All	4.2.5.2	n/a
Nonpoint (afdust, ag, nonpt, np_oilgas and rwc sectors) Growth and Control Assumptions					
AEO-based VMT growth for paved and unpaved roads	afdust	PROJECTION	PM	4.2.3.1	1
Livestock emissions growth from year 2011 to year 2023	ag	PROJECTION	NH_3	4.2.3.2	1
Upstream RFS2/EISA/LDGHG impacts on gas distribution, pipelines and refineries to years 2018	ptnonipm, pt_oilgas, nonpt	PROJECTION	All	4.2.3.4	2
AEO-based growth: industrial sources, including oil and gas regional projections	ptnonipm, pt_oilgas, nonpt, np_oilgas	PROJECTION	All	4.2.3.5	1
NESHAP: RICE (reciprocating internal combustion engines) with reconsideration amendments	ptnonipm, pt_oilgas, nonpt, np_oilgas	CONTROL	CO, NO_X, PM, SO_2, VOC	4.2.4.2	1
NSPS: oil and gas	pt_oilgas, np_oilgas	CONTROL	VOC	4.2.4.1	1
NSPS: RICE	ptnonipm, pt_oilgas, nonpt, np_oilgas	CONTROL	CO, NO_X, VOC	4.2.4.3	2
Residential wood combustion growth and change-outs	rwc	PROJECTION	All	4.2.3.9	1
Industrial/Commercial/Institutional Boiler MACT with Reconsideration Amendments + local programs	nonpt, ptnonipm, pt_oilgas	CONTROL	CO, NO_X, PM, SO_2, VOC	4.2.4.4	1
State fuel sulfur content rules for fuel oil – via 2018 NODA comments, effective only in most northeast states	nonpt, ptnonipm, pt_oilgas	CONTROL	SO_2	4.2.4.5	1
State comments: from previous platforms (including consent decrees) and NODAs	nonpt, ptnonipm, pt_oilgas	PROJECTION & CONTROL	All	4.2.3.5, 4.2.4.11	1

Description of growth, control, closure data, or, new inventory	Sector(s)	Packet Type	CAPs impacted	Section(s)	CoST Strategy
MSAT2 and RFS2 impacts with state comments on portable fuel container growth and control from 2011 to years 2018	nonpt	new inventory	All	4.2.5.1	n/a
New cellulosic plants in year 2018	nonpt	new inventory	All	4.2.5.3	n/a
Onroad Mobile (onroad sector) Growth and Control Assumptions **All national in-force regulations are modeled. The list includes recent key mobile source regulations but is not exhaustive.**					
National Onroad Rules:					
All onroad control programs finalized as of the date of the model run, including most recently:	onroad	n/a	All	4.3	n/a
Tier-3 Vehicle Emissions and Fuel Standards Program: March, 2014					
2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas 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					
Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule for Model-Year 2012-2016: May, 2010					
Final Mobile Source Air Toxics Rule (MSAT2): February, 2007					
Local Onroad Programs:					
California LEVIII Program	onroad	n/a	All	4.3	n/a
Ozone Transport Commission (OTC) LEV Program: January,1995					
Inspection and Maintenance programs					
Fuel programs (also affect gasoline nonroad equipment)					
Stage II refueling control programs					
Nonroad Mobile (cmv, rail, nonroad sectors) Growth and Control Assumptions **All national in-force regulations are modeled. The list includes recent key mobile source regulations but is not exhaustive.**					
National Nonroad Programs:					
All nonroad control programs finalized as of the date of the model run, including most recently:	nonroad	n/a	All	4.3.2	n/a
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					
Clean Air Nonroad Diesel Final Rule – Tier 4: May, 2004					
Locomotives:					
Growth and control from Locomotives and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder: March, 2008	cmv, rail ptnonipm	PROJECTION	All	4.2.3.3	1, 2
Clean Air Nonroad Diesel Final Rule – Tier 4: May, 2004	cmv, rail	n/a	All	4.3.2	n/a
Commercial Marine:					
Category 3 marine diesel engines Clean Air Act and International Maritime Organization standards: April, 2010	cmv	PROJECTION	All	4.2.3.3	1

Description of growth, control, closure data, or, new inventory	Sector(s)	Packet Type	CAPs impacted	Section(s)	CoST Strategy
Growth and control from Locomotives and Marine Compression-Ignition Engines Less than 30 Liters per Cylinder: March, 2008	cmv, rail, ptnonipm	PROJECTION	All	4.2.3.3	1, 2
Clean Air Nonroad Diesel Final Rule – Tier 4: May, 2004	nonroad	n/a	All	4.3.2	n/a

4.1 EGU sector projections (ptegu)

4.1.1 Engineering Analysis Estimates for 2023 Flat File

A flat file in a format that can be input to SMOKE was prepared for the 2023en case. The underlying data and calculations used in the development of this flat file, which are described below can be found in the workbook titled *Engineering_Analysis_2023_Unit_File.xlsx* available in the "Data Files and Summaries" on the 2011v6.3 platform web page https://www.epa.gov/air-emissions-modeling/2011-version-63-platform, more specifically it can be found in the FTP area ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/reports/2011en_and_2023en/. The following spreadsheets detail some of the computations described in this section are also available via FTP: *2023en_New_Unit_Capacity_Factor_Calcs.xlsx*, *2023en_Non_NOx_non_SO2_pollutants_for_eng_analysis.xlsx*, and *2023en_Generation_Surplus_Deficit_Calcs.xlsx*. The spreadsheet 2023en_egu_summer_emissions_comparison_30sep2017.xlsx provides a comparison of the 2023 summer EGU emissions with emissions in 2011 and 2016.

4.1.1.1 SO2 and NOx emissions for units reporting under Part 75 for EPA Acid Rain Program (ARP) and Cross State Air Pollution Rule (CSAPR)

EPA starts with 2016 reported, seasonal, historical emissions for each unit. This reflects the latest owner/operator reported data available at the time of EPA analysis. The emissions data for NO_x and SO_2 for units that report data to CAMD under either the Acid Rain Program (ARP) and/or the Cross-State Air Pollution Rule (CSAPR) are aggregated to the summer/ozone season period (May-September) and winter/non-ozone period (January-April and October-December).[27] Unit-level details such as plant name, unit ID, unit type, etc. are shown in columns A through F. Reported historical data for these units such as historical emissions, heat input, generation, etc. are shown in columns G through J. The 2016 historical emissions value is in column J. The projected 2023 emissions estimate is shown in column K, and reflects either the same emissions level as reported for 2016, or a modification of that value based on adjustments to the operational or pollution control status of that unit.[28] Because the 2016 data preceded implementation of certain NO_X reduction programs (e.g., CSAPR Update, Pennsylvania RACT, and Connecticut RACT), EPA made assumptions about how EGUs would adjust their operations and emissions in order to comply with such programs in 2023. With respect to the CSAPR Update, the agency made assumptions about EGU operations in steps four and five, below. CSAPR Update compliance is demonstrated through an ozone season NO_X allowance trading program, which provides flexibility for EGU owner/operators to determine their own compliance path. As such, the assumptions that EPA applies for the purpose of developing the 2023 EGU emission projection represent one reasonable compliance path, but not the only compliance path, for EGUs in CSAPR Update states. The modifications to operational or pollution control status are made due to:

1. *Retirements* - Emissions from units with upcoming confirmed retirement dates prior to 2023 are

[27] The EPA notes that historical state-level ozone season EGU NO_x emission rates are publically available and quality assured data. They are monitored using continuous emissions monitors (CEMs) data and are reported to the EPA directly by power sector sources. They are reported under Part 75 of the CAA.

[28] Based on data and changes known as of 8/11/2017.

adjusted to zero. Retirement dates are identified through a combination of sources including EIA 860, utility-announced retirements, and stakeholder feedback provided to EPA. The impact of retiring on emissions is shown in column K. These 269 retiring units are flagged in column L and noted as "Retiring" in column M.

	2016	2023
Unit X	10,000 mmBtu x .2 lb/mmBtu = 1 ton	**0 mmBtu** x .2 lb/mmBtu = **0 ton**

2. *Coal to Gas Conversion* – Emissions from units with scheduled conversion to natural gas fuel use by 2023 are adjusted to reflect reduced emission rates associated with natural gas. To reflect a given unit's conversion to gas, that unit's 2023 emission rates for NO_x are assumed to be half of its 2016 coal-fired emission rates, and the unit's SO_2 emissions rates are adjusted to zero while utilization levels are assumed to remain the same.[29] Therefore, the 2023 projected emissions for these converting units are estimated to be half of 2016 levels for NO_x, and zero for SO_2. Units expected to convert to gas are flagged using EIA 860 and stakeholder feedback. The impact of coal to gas conversion for 2023 is shown in column K, flagged in column L, and noted as "coal to gas conversion" in column M. The example below pertains to NO_x emission estimates.

	2016	2023
Unit X	10,000 mmBtu x .2 lb/mmBtu = 1 ton	10,000 mmBtu x **.1 lb/mmBtu** = **.5 ton**

3. *Retrofits* – Emissions from units with scheduled SCR, SNCR and/or FGD retrofits prior to 2023 are adjusted to reflect the emission rates expected with new SCR installation (.075 lb/mmBtu of NO_x), new SNCR (a 25% decrease in emission rate), and/or new FGD (0.06 lb/mmBtu of SO_2) and are assumed to operate at the same 2016 utilization levels.[30] These emission rates were multiplied by the affected unit's 2016 heat input to estimate the 2023 emission level. The impact of post-combustion control retrofits on 2023 emissions assumptions is shown in column K, flagged in column L, and noted as "New SCR", "New SNCR" or "New FGD" in column M.

For SCR:

	2016	2023
Unit X	10,000 mmBtu x .2 lb/mmBtu = 1 ton	10,000 mmBtu x **.075 lb/mmBtu = .38 ton**

For SNCR

	2016	2023
Unit X	10,000 mmBtu x .2 lbs/mmBtu = 1 ton	10,000 mmBtu * **.15 lbs/mmBtu = .75 ton**

4. *State-of-the- art combustion controls* – Emissions from units in the CSAPR update region that were operating in 2016 without state-of-the-art combustion controls were adjusted downwards to reflect assumed installation of these controls and their expected emission rate impact. EPA assumed a 2023 emission rate of 0.1549 lbs/mmBtu for units with dry bottom wall-fired boilers expected to install/upgrade combustion controls, and 0.139 lbs/mmBtu for tangentially-fired coal units expected to install upgrade combustion controls. These emission rates were multiplied by each unit's 2016 heat input to estimate its 2023 emission level. Details of EPA's assessment of state-of-the-art NO_x combustion controls and corresponding emission rates are provided in the EGU NO_x Mitigation Strategies Final Rule TSD.[31] The impact on state-of-the-art combustion controls on 2023 emission assumptions is shown in column K, flagged in column L, and noted as

[29] See NO_x Mitigation Strategy TSD available at https://www.epa.gov/sites/production/files/2017-05/documents/egu_nox_mitigation_strategies_final_rule_tsd.pdf
[30] *Ibid.*
[31] *Ibid.*

"Install state-of-the-art combustion controls" in column M. EPA identified 47 such units that it flagged as likely to receive such control upgrades.

	2016	2023
Unit X	10,000 mmBtu x .2 lb/mmBtu = 1 ton	10,000 mmBtu x **.139 lb/mmBtu = .7 ton**

5. *SCR optimization* – Emissions from units with existing SCRs in the CSAPR update region, but that operated at an emission rate greater than 0.10 lb/mmBtu in 2016, were adjusted downwards to reflect emissions when the SCR is operated to achieve a 0.10 lb/mmBtu emission rate. This emission rate was identified as achievable and regionally cost-effective under the CSAPR Update, and represents one reasonable compliance path for the purposes of this EGU projection.[32] The optimized emission rate is multiplied by 2016 heat input levels to arrive at the 2023 emissions estimate. For the 80 units affected by this adjustment, the impact on 2023 emission assumptions is shown in column K, flagged in column L, and noted as "Optimize SCR to 0.10 lb/mmBtu" in column M. Note, this assumption only applies to ozone-season NOx as that is the season in which the CSAPR Update compliance is required.

	2016	2023
Unit X	10,000 mmBtu x .2 lb/mmBtu = 1 ton	10,000 mmBtu x **.1 lb/mmBtu = .5 ton**

6. *New Units* – Emissions were adjusted up from 2016 levels of zero to reflect firm units that are under development (e.g., under construction units) greater than 25 MW that are expected to be in commercial operation by 2023. These assumed emission values for 156 new units are reflected in columns K, flagged in column L, and noted as "new unit > 25 MW" in column M". To obtain these emissions, EPA identified all new fossil-fired EGUs coming online after 2016 according to EIA Form 860 and stakeholder comments. EPA then identified the heat rate and capacity values for these units using EIA 860 and stakeholder-provided data. Next, EPA identified the 2016 average seasonal capacity factor for similar units that came online between 2011 and 2015. EPA used these seasonal capacity factors (e.g., 65% for NGCC in the summertime and 53.4% in the wintertime), the unit's capacity, the unit's heat rate, and the unit's estimated NO_x rate to estimate 2023 emissions (capacity factor × capacity × number of hours × heat rate × NO_x emission rate = NO_x emissions). The underlying data and calculations for these new unit emission estimates are available on EPA's website at the link provided in Section 1.

	2016	2023
Unit X	0 mmBtu x 0 lb/mmBtu = 0 ton	**100 MW x .65 x 8760 hours x 8000 Btu/KWh * 01 lb/mmBtu = 22 tons**

7. *Other* – EPA also made several unit-specific adjustments to 2016 emission levels to reflect forthcoming emission or emission rate requirements specified in consent decrees, BART requirements, and/or other revised permit limits. The impacts for 2023 emission assumptions are shown in column K, flagged in column L, and noted as such in column M (e.g., values of "CT RACT" mean that they were adjusted to reflect the impacts of the Connecticut Reasonably Available Control Technology (RACT) implementation).[33] EPA assumes that the the Pennsylvania RACT rule would result in units with existing SCRs operating at 0.12lb/mmBtu year-round. However, these same units are also adjusted to operate at 0.10lb/mmBtu during the ozone season in response to the CSAPR Update. Therefore, the Pennsylvania RACT does not

[32] 81 FR 74543

[33] EPA's adjustments to Connecticut EGU emissions for the purpose of representing compliance with Connecticut's RACT rule for 2023 reflect one potential compliance path, but not the only path, available under this state rule.

impact EPA's ozone-season emission assumptions for EGUs, but it does impact emission assumptions outside of the ozone season.

4.1.1.2 SO_2 and NO_x emissions for units not reporting under Part 75 for EPA ARP and CSAPR

All non-CAMD unit EGU SO_2 and NO_X emissions are taken directly from the 2011 NEI with the exception of 10 units known to be retired before 2023. These 10 units have emissions adjusted to zero. These units are Ben French (ORIS 3325 Unit 1), Chalk Cliff Cogen (ORIS 50003 Unit GEN1), Killen Station (ORIS 6031 GT1), James De Young (ORIS 1830 Unit 4), Prairie Creek (ORIS 1073 Units 1 and 2), Kennecott Power Plant (ORIS 56163 Unit 1, 2, 3), and Hutchinson Energy Center (ORIS 1248 Unit GT4).

4.1.1.3 Other pollutants

While NO_x and SO_2 are the primary pollutants of interest for the 2023 flat file when evaluating the 2008 ozone NAAQS, there are also air quality modeling inputs for other criteria pollutants including CO, NH3, PM_{10} filterable, PM_{10} primary, $PM_{2.5}$ filterable, $PM_{2.5}$ primary, PM Condensable, and VOC. For the units that do not report under CAMD programs, EPA used the 2011 NEI emission values (with the limited exceptions noted in section 2 for retirements). For units that do report data under an EPA emission program, EPA used 2011 NEI values, but made t adjustments to reflect most recent year (2016) utilization. For example, if heat input increased by 10% from 2011 to 2016 for the unit, then emissions were adjusted upwards by 10%. EPA also used source classification code (SCC)-based emission factors to adjust emissions for units that switched primary fuel between 2011 and 2016. Finally, EPA made limited modifications to emissions to reflect changes in control status. EPA flagged units that received a FGD between 2011 and 2023, for which EPA then adjusted emissions for PM_{10} and $PM_{2.5}$ based on emission rates for similarly controlled units.

4.1.1.4 Comparing future utilization and generation levels to regional load requirements

EPA analyzed and confirmed that assumed fleet operations in its emissions estimates were compatible with future load requirements by verifying that new units would provide enough generation, assuming technology-specific capacity factors, to replace the retiring generation expected to occur by 2023. EPA assessed generation adequacy at both the national level, Interconnect, and at the level of eight National Electric Reliability Council (NERC) regions.

- EPA identified the 2017 Energy Information Administration's Annual Energy Outlook (EIA AEO) growth projections from 2016 to 2023 electricity demand levels (195 TWh) from its No CPP reference case.
- Next, EPA identified the amount of retiring generation assumed in its engineering analysis (103 TWh).[34]
- EPA added these two values together (195 TWh + 103 TWh = 298 TWh) to identify the total amount of electricity generation that would need to be provided by new units assuming non-retiring units continued to collectively generate at 2016 levels.
- EPA then identified planned new capacity as that listed in EIA form 860 as "under construction", "testing", or "site prep". EPA also included other stakeholder-reported new capacity.

[34] This is *gross* generation, not *net*, and therefore slightly over-estimates the generation deficit created by retiring units. This is a conservative assumption for the analysis of determining if sufficient generation will exist to meet load.

- Using technology-specific capacity factors[35] based on past performance and IPM documentation, EPA anticipated 249 TWh from new generation already under construction. This left a remaining load of (298-249 = 49 TWh).

Primary Fuel	New Capacity (site prep, under construction, or testing phase) (MW)	Assumed Annual Capacity Factor	Annual Generation TWh
Gas (including CCs and CTs)	28,358	70%	173.9
Nuclear	4,434	90%	35.0
Other	231	10%	0.1
Petroleum	40	10%	0.04
Solar	2,840	21.6%	5.4
Wind	9,142	42.7%	34.2
Water	270	10%	0.2
Total	**45,315**		**248.9**

- EPA then identified additional expected new generation by looking at 1) "pending" and "permitted" generation from EIA 860, stakeholder comments, and data collection services which equaled 472 TWh if all constructed, and 2) applying the minimum expected continued build rate for new solar and wind forward from 2019 through 2022 (resulting in 169 TWh of additional generation).[36][37] The expected continued build rate for solar and wind was equal to the solar and wind capacities for projects that had been identified as Application Pending, Permitted, Site Preparation, Under Construction, or Testing expected to come online in 2017. These build rates are 5,851 MW of solar and 11,074 MW of wind.[38]
- EPA combined the new generation that has been either "pending" or "permitted" along with the business as usual renewable capacity growth trends to identify up to 641 TWh of additional new generation.
- The potential new generation (641 TWh) is significantly greater than the 49 TWh generation gap identified in the bullet above, suggesting that available generation would easily exceed load requirements.
- EPA repeated this analysis at the three main interconnects and at the regional levels and found similar affirmation that potential generation levels consistent with these 2023 projections would significantly exceed demand levels.
- Finally, each state's projected 2023 emissions are compared to final CSAPR Update Rule state assurance levels to verify they do not exceed those levels.

4.1.1.5 NERC Region Generation Evaluation

EPA repeated the same analysis described in the previous section for each of the NERC Regions. First, the change in demand and generation lost from retiring units was calculated for each region as shown in Table 4-2,

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[35] Assumed annual capacity factors are estimates of achievable and demonstrated capacity factors and are slightly different than the capacity factors used in the analysis to determine emissions from new EGUs. The results of this analysis do not change if these capacity factors slightly different.

[36] Because of relatively short build times for solar and wind facilities, it is unlikely that units coming on line post 2019 would be listed as "under construction" in current data sets.

[37] The total amount of new RE generation assumed in the exercise is conservative relative to AEO 2017 No CPP reference Case projections regarding RE generation growth by 2023. AEO projected an additional 349 TWh, while EPA assumes just 315 TWh.

[38] For example, in 2019, there are 1,762 MW of known solar projects in the pipeline. This calculation would add an additional 4,089 MW to equal the 2017 new build rate of 5,851 MW.

then, EPA calculated the "firm" new capacity being built in each region as shown in Table 4-3. The EPA also calculated the new capacity that was classified as permitted or application pending as shown in Table 4-4 and the expected generation from the "firm" new capacity as shown in Table 4-11.

Table 4-2. Change in demand and generation lost from retiring units for each region

NERC Region	Demand 2016 (TWh)	Demand 2023 (TWh)	Demand Change 2016 to 2023 (TWh)	Demand Change (percent)	mmBtu Retiring Units	Gen from retiring units (est. *gross*) (TWh)
ERCOT	351	380	29	8%	51,847,646	6
FRCC	208	208	0	0%	95,084,124	9
MRO	217	242	25	12%	27,582,891	2
NPCC	249	237	-12	-5%	32,217,183	3
RFC	931	928	-4	0%	280,926,895	29
SERC	1,015	1,076	61	6%	262,357,655	26
SPP	214	266	51	24%	50,532,303	5
WECC	710	755	45	6%	257,222,349	24
Total	**3,896**	**4,091**	**195**	**5%**	**1,057,771,045**	**103**

Table 4-3. "Firm" new capacity being built in each region: Site Prep, Under Construction, Testing (MW)

NERC Region	Gas (CCs and CTs)	Nuclear	Other	Petroleum	Solar	Wind	Water
ERCOT	3,866		28.6		207	2,386	
FRCC	1,640		15		80		
MRO	700		0		11	280	55
NPCC	2338		24.2	24.65	160	88	1.55
RFC	13,777		83.1	1	260	1,559	6
SERC	5,153	4,434	5	14.4	1,042		127.36
SPP			0			3,164	
WECC	884		75.432		1,080	1,665	80.3
Total	**28,358**	**4,434**	**231**	**40**	**2,840**	**9,142**	**270**

Table 4-4. New capacity classified as permitted or application pending

	Permitted, Application Pending (MW)						
NERC Region	Gas (including CCs and CTs)	Nuclear	Other	Petroleum	Solar	Wind	Water
ERCOT	240	19,804	2,716	317	1,004	4,114	
FRCC		2,140		0			
MRO	200	345		3	4	3,111	
NPCC		4,861		42	16	1,007	283
RFC	775	10,721		60	141	2,972	386
SERC		4,516	4,060	13	1,825	861	141

SPP	895	687		270	239	2,347	77
WECC		5,359		525	8,462	8,156	3,875
Total	**2,110**	**48,434**	**6,776**	**1,230**	**11,690**	**22,569**	**4,763**

Table 4-5. Expected generation from the "firm" new capacity

	Generation (TWh) from "Firm Units" (Site Prep, Under Construction, Testing)						
NERC Region	**Gas (including CCs and CTs)**	**Nuclear**	**Other**	**Petroleum**	**Solar**	**Wind**	**Water**
ERCOT	24	0	0	0	0	9	0
FRCC	10	0	0	0	0	0	0
MRO	4	0	0	0	0	1	0
NPCC	14	0	0	0	0	0	0
RFC	84	0	0	0	0	6	0
SERC	32	35	0	0	2	0	0
SPP	0	0	0	0	0	12	0
WECC	5	0	0	0	2	6	0
Total	**174**	**35**	**0**	**0**	**5**	**34**	**0**

The EPA also calculated the expected generation from the "permitted" and "application pending" generation as shown in Table 4-12. The EPA then combined this information to determine the surplus or deficit of generation in each NERC region. This was calculated twice, once considering only "firm" new generation, and again including generation that has a status of permitted or application pending as shown in Table 4-7. For the latter calculation, the EPA found that only two regions, MRO and SPP, had deficits of generation. The EPA also calculated the surplus or deficit for each region as a percentage of total 2023 demand as shown in Table 4-14.

Table 4-6. Expected generation from "permitted" and "application pending" units

	Generation (TWh) from Unit Permitted, Application Pending						
NERC Region	**Gas (including CCs and CTs)**	**Nuclear**	**Other**	**Petroleum**	**Solar**	**Wind**	**Water**
ERCOT	1	121	21	0	2	15	0
FRCC	0	13	0	0	0	0	0
MRO	1	2	0	0	0	12	0
NPCC	0	30	0	0	0	4	0
RFC	4	66	0	0	0	11	0
SERC	0	28	32	0	3	3	0
SPP	4	4	0	0	0	9	0
WECC	0	33	0	0	16	31	3
Total	**10**	**297**	**53**	**1**	**22**	**84**	**4**

Table 4-7. Review of surplus or deficit generation for each region (TWh)

NERC Region	2023 Demand	Demand Change from 2016	Gen from retiring units (est. *gross*)	New Gen.from "Firm Units" (Site Prep, under Construction, and Testing)	New Gen. from Permitted and Application Pending Units	Total New Generation	Increased Demand + Retiring Gen - New Firm Generation (Surplus or Deficit)	Increased Demand + Retiring Gen - New Total Generation (Surplus or Deficit)
ERCOT	380	29	6	33	162	195	2	-160
FRCC	208	0	9	10	13	23	-2	-15
MRO	242	25	2	5	15	20	21	7
NPCC	237	-12	3	15	34	49	-24	-58
RFC	928	-4	29	91	81	172	-66	-147
SERC	1,076	61	26	69	67	135	17	-49
SPP	266	51	5	12	18	30	44	26
WECC	755	45	24	14	83	97	56	-28
Total	**4,091**	**195**	**103**	**249**	**472**	**721**	**49**	**-424**

(for the last two columns, positive numbers are deficits, negative numbers are surpluses)

Table 4-8. Surplus or deficit generation as a fraction of total demand

NERC Region	Surplus/Deficit as a fraction of total demand (firm new units only)	Surplus/Deficit as a fraction of total demand (all new units)
ERCOT	0%	-42%
FRCC	-1%	-7%
MRO	9%	3%
NPCC	-10%	-24%
RFC	-7%	-16%
SERC	2%	-5%
SPP	17%	10%
WECC	7%	-4%
Total	**1%**	**-10%**

(positive numbers are deficits; negative numbers are surpluses)

Overall, EPA found that firm new units were close to being able to fill the gap created by increased demand and units expected to retire by 2023. Considering units that are either permitted or application pending, there is a significant surplus of generation. There was however some regional variation, with MRO and SPP having generation deficits when just considering all units permitted or with applications pending.

However, as described in the previous section, there are several additional sources of generation not captured in these projects, including additional solar and wind projects. Because of shorter construction times, not all RE generation expected to be online by 2023 is in the "under construction, testing, permitting, pending, site prep" phase. But assuming that new RE capacity build continues forward at levels greater than or equal to recent years, this additional generation would fill the deficits in these regions. For example, there were 2,505 MW of wind projects in the development pipeline (Application Pending, Permitted, Site Preparation, Under Construction, or Testing) expected to come online in SPP in 2017. If that rate of development continued in 2018 through 2022, an additional 9,519 MW of wind capacity that is not captured in this analysis would we added, resulting in an additional estimated 35.6 TWh of electricity. That generation would be sufficient to cover the 26 TWh deficit calculated for SPP. A similar dynamic in MRO would lead to an additional 3,007 MW and 11.2 TWh of generation from wind.[39]

In addition to increases in capacity, it is also possible that electricity could be transmitted from regions with surpluses to regions with deficits. The Eastern, Western, and Texas Interconnections all have generation surpluses in the tables above.

4.1.2 Connecticut Municipal Waste Combustor Reductions

The Connecticut Department of Energy and Environmental Protection provided comments on the 2011v6.3 platform NODA regarding reductions for municipal waste combustors in the state of Connecticut as a result of a MWC regulation in support of the Connecticut RACT certification (82 FR 35454, July 31, 2017; http://www.ct.gov/deep/cwp/view.asp?a=2684&q=546804). These requirements are effective as of August 2, 2017 and the resulting impacts due to a projected reduction in usage have been incorporated as shown in Table 4-9. These reductions, which are applied to all pollutants, were calculated from information found in the Revision to Connecticut's SIP (http://ct.gov/deep/lib/deep/air/ozone/ozoneplanningefforts/SouthwestConnecticutAttainmentSIPDRAFTFINAL.pdf), and include the closure of the Covanta Projects of Wallingford units. In addition, Connecticut tightened NOx emissions limits for most types of combustion equipment using a two-phased approach, with requirements for Phase 1 beginning in June, 2018 and phase 2 limits in June, 2023. The state provided some information on the Phase 1 impacts which are included in this modeling, but Phase 2 impacts were not quantified.

Table 4-9. Connecticut MWC Emission Reductions for 2023

Facility name	EIS Facility ID	EIS Unit ID	Emission Reduction (%)
Covanta Bristol, INC	588711	46157913	6.11
Covanta Bristol, INC	588711	46158013	6.11
Covanta Projects of Wallingford	589911	46137513	100
Covanta Projects of Wallingford	589911	46137613	100
Covanta Projects of Wallingford	589911	46137713	100
C R R A / Mid-Connecticut	715611	46362613	6.11
C R R A / Mid-Connecticut	715611	46362713	6.11
C R R A / Mid-Connecticut	715611	46362913	6.11
Wheelabrator Bridgeport LP	754411	46285513	36.38
Wheelabrator Bridgeport LP	754411	46285613	36.38
Wheelabrator Bridgeport LP	754411	46285713	36.38
Covanta Southeastern CT CO	754611	46284313	6.11
Covanta Southeastern CT CO	754611	46284413	6.11
Wheelabrator Lisbon INC (WM)	8501611	961813	6.11
Wheelabrator Lisbon INC (WM)	8501611	962013	6.11

[39] This may be a conservative estimate as it's based on MRO's 2017 wind build rate of 853 MW. However, in 2019, the build rate of projects in the pipeline is expected to be 2,132 MW.

4.2 Non-EGU Point and NEI 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 2011 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 these sectors.

In recent platforms, the EPA has assumed that emissions growth for most industrial sources did not track with economic growth for most stationary non-IPM sources (EPA, 2006b). This "no-growth" assumption was based on an examination of historical emissions and economic data. Recently however, the EPA has received growth (and control) data from numerous states and regional planning organizations for many industrial sources, including the rapidly-changing oil and gas sector. The EPA provided a Notice of Data Availability for the 2011v6.0 emissions modeling platform and projected 2018 inventory in January, 2014 (Docket Id. No. EPA-HQ-OAR-2013-0809). The EPA requested comment on the future year growth and control assumptions used to develop the 2018 inventories. One of the most frequent comments the EPA received was to use the growth factors information that numerous states either provided or deferred to growth factors provided by broader region-level efforts. In an attempt to make the projections approach as consistent as possible across all states, the EPA decided to expand this effort to all states for some of the most-significant industrial sources (see Section 4.2.3).

Because much of the projections and controls data are developed independently from how the EPA defines its emissions modeling sectors, 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 CoST in combination with other methods to produce future year inventories: 1) for point sources, apply plant (facility or sub-facility-level) closure information via CoST; 2) apply all PROJECTION packets via CoST (multiplicative factors that could cause increases or decreases); 3) apply all percent reduction-based CONTROL packets via CoST; and 4) append all 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.

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 2011 NEI-based emissions modeling inventories to create future year inventories for the following sectors: afdust, ag, cmv, rail, nonpt, np_oilgas, ptnonipm, pt_oilgas and rwc. Information about CoST and related data sets is available from https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-analysis-modelstools-air-pollution.

CoST allows the user to apply projection (growth) factors, controls and closures at various geographic and inventory key field resolutions. Each of these CoST datasets, also called "packets" or "programs," provides the user with the ability to perform numerous quality assurance assessments as well as create SMOKE-ready future year inventories. Future year inventories are created for each emissions modeling sector via a CoST "strategy" and each strategy includes all base year 2011 inventories and applicable CoST packets. For reasons discussed later, some emissions modeling sectors 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 measures 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 as described below:

1. CLOSURE: 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 stack. The EPA uses these types of packets for known post-2011 controls as well as information on closures provided by states on specific facilities, units or stacks. This packet type is only used in the ptnonipm and pt_oilgas sectors.
2. PROJECTION: This packet allows the user to increase or decrease emissions for virtually any geographic and/or inventory source level. Projection factors are applied as multiplicative factors to the 2011 emissions inventories prior to the application of any possible subsequent CONTROLs. A PROJECTION packet is necessary whenever emissions increase from 2011 and is also desirable when information is based more on activity assumptions rather than known control measures. The EPA uses PROJECTION packet(s) in every non-EGU modeling sector.
3. CONTROL: These packets are applied after any/all CLOSURE and PROJECTION packet entries. The user has similar level of control as PROJECTION packets regarding specificity of geographic and/or inventory source level application. Control factors are expressed as a percent reduction (0 to 100) and can be applied in addition to any pre-existing inventory control, or as a replacement control where inventory controls are first backed out prior to the application of a more-stringent replacement control.

All of 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 2011NEI) 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 2011 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 4-10, although the fields in Table 4-10 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 4-4 includes corrections to matching hierarchy made in 2011v6.3 platform modeling. These corrections did cause emissions changes from the 2011v6.2 platform to 2011v6.3 platform for the np_oilgas, pt_oilgas, ptnonipm and nonpt sectors.

Table 4-10. 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
19	REGION_CD, NAICS, SCC	point, nonpoint
20	REGION_CD, NAICS	point, nonpoint
21	STATE, NAICS, SCC	point, nonpoint
22	STATE, NAICS	point, nonpoint
23	NAICS, SCC	point, nonpoint
24	NAICS	point, nonpoint
25	REGION_CD, SCC, POLL	point, nonpoint
26	STATE, SCC, POLL	point, nonpoint
27	SCC, POLL	point, nonpoint
28	REGION_CD, SCC	point, nonpoint
29	STATE, SCC	point, nonpoint
30	SCC	point, nonpoint
31	REGION_CD, POLL	point, nonpoint
32	REGION_CD	point, nonpoint
33	STATE, POLL	point, nonpoint
34	STATE	point, nonpoint
35	POLL	point, nonpoint

The contents of the controls, local adjustments and closures for the future year base case are described in the following subsections. Year-specific projection factors (PROJECTION packets) for the future year were used to create the future year base case, 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 4-5. Note that future year inventories were used rather than projection or control packets for some sources.

Table 4-11. 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	Paved and unpaved roads VMT growth	afdust	PROJECTION packet: county-level resolution, based on VMT growth.
4.2.3.2	Livestock population growth	ag	PROJECTION packet: national, by-animal type resolution, based on animal population projections.
4.2.3.3	Locomotives	rail, ptnonipm	PROJECTION packet: Rail projections are by FIPS/SCC/poll for Calif. And SCC/poll for rest of US. NC rail projection packet was added for NODA, by FIPS/SCC/poll.
4.2.3.3	Category 1, 2, and 3 commercial marine vessels	cmv	PROJECTION packet: Category 1 & 2: CMV uses SCC/poll for all states except Calif. Category 3: region-level by-pollutant, based on cumulative growth and control impacts from rulemaking.
4.2.3.4	OTAQ upstream distribution, pipelines and refineries	nonpt, ptnonipm, pt_oilgas	PROJECTION packet: national, by-broad source category, based on upstream impacts from mobile source rulemakings.
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, to oil/gas play-level and by-process/fuel-type applications. Data derived from AEO2016 with several modifications.
4.2.3.6	Aircraft	ptnonipm	PROJECTION packet: by-airport for all direct matches to FAA Terminal Area Forecast data, with state-level factors for non-matching NEI airports.
4.2.3.7	Cement manufacturing	ptnonipm	PROJECTION packet: by-kiln projections based on Industrial Sectors Integrated Solutions (ISIS) model of demand growth and Portland Cement NESHAP.
4.2.3.8	Corn ethanol plants	ptnonipm	PROJECTION packet: national, based on 2014 AEO renewable fuel production forecast.
4.2.3.9	Residential wood combustion	rwc	PROJECTION packet: national with exceptions, based on appliance type sales growth estimates and retirement assumptions and impacts of recent NSPS.

Subsection	Title	Sector(s)	Brief Description
4.2.4	CoST CONTROL packets	nonpt, np_oilgas, ptnonipm, pt_oilgas	Introduces and summarizes national impacts of all CoST CONTROL packets in the future year.
4.2.4.1	Oil and gas NSPS	np_oilgas, pt_oilgas	CONTROL packet: national, oil and gas NSPS impacting VOC only for some activities.
4.2.4.2	RICE NESHAP	nonpt, np_oilgas, ptnonipm, pt_oilgas	CONTROL packet: national, reflects NESHAP amendments on compression and spark ignition stationary reciprocating internal combustion engines (RICE).
4.2.4.3	RICE NSPS	nonpt, np_oilgas, ptnonipm, pt_oilgas	CONTROL packet: state and county-level new source RICE controls, whose reductions by-definition, are a function of growth factors and also equipment retirement assumptions.
4.2.4.4	ICI Boilers	nonpt, ptnonipm, pt_oilgas	CONTROL packet: by-fuel, and for point sources, by-facility-type controls impacting Industrial and Commercial/Institutional boilers from rulemaking and state-provided information.
4.2.4.5	Fuel sulfur rules	nonpt, ptnonipm, pt_oilgas	CONTROL packet: state and MSA-level fuel sulfur control programs provided by several northeastern U.S. states.
4.2.4.6	Natural gas turbines NSPS	ptnonipm, pt_oilgas	CONTROL packet: state and county-level new source natural gas turbine controls, whose reductions by-definition, are a function of growth factors and also equipment retirement assumptions.
4.2.4.7	Process heaters NSPS	ptnonipm, pt_oilgas	CONTROL packet: state and county-level new source process heaters controls, whose reductions by-definition, are a function of growth factors and also equipment retirement assumptions.
4.2.4.8	Arizona Regional Haze	ptnonipm	CONTROL packet: Regional haze controls for Arizona provided by Region 9.
4.2.4.9	CISWI	ptnonipm	CONTROL packet reflecting EPA solid waste rule cobenefits.
4.2.4.11	Data from comments on previous platforms	nonpt, ptnonipm, pt_oilgas	CONTROL packets for all other programs, including Regional Haze, consent decrees/settlements, and other information from states/other agencies in prior platforms.
4.2.5	Stand-alone future year inventories	nonpt, ptnonipm	Introduction to future-year inventories not generated via CoST strategies/packets.
4.2.5.1	Portable fuel containers	nonpt	Reflects impacts of Mobile Source Air Toxics (MSAT2) on PFCs.
4.2.5.2	Biodiesel plants	ptnonipm	Year 2018 new biodiesel plants provided by OTAQ reflecting planned sited-plants production volumes.
4.2.5.3	Cellulosic plants	nonpt	Year 2018 new cellulosic ethanol plants based on cellulosic biofuel refinery siting provided by OTAQ and 2018 NODA.

Subsection	Title	Sector(s)	Brief Description
4.2.5.4	New cement plants	nonpt, ptnonipm	Year 2018 policy case-derived new cement kilns, permitted (point) and model-generated based on shifted capacity from some closed units to open units (nonpt)

4.2.2 CoST Plant CLOSURE Packet (ptnonipm, pt_oilgas)

Packet: "CLOSURES_2011v6_2_v5_18aug2017_nf_v1"

The CLOSURES packet contains facility, unit and stack-level closure information derived from the following sources:

1. Emissions Inventory System (EIS) facilities report from August 1, 2017 with closure status equal to "PS" (permanent shutdown);
2. input on closures provided by states in summer 2017 including Georgia, Illinois, Kansas, Michigan, Missouri, Minnesota, North Carolina, Ohio, Virginia, West Virginia, and Wisconsin;
3. concatenation of all 2011v6.0 closures information; see Section 4.2.11.3 from the 2011v6.0 platform TSD;
4. comments from states and regional planning organizations on the 2011v6.2 platform for states including Oklahoma; and
5. closures provided by MARAMA with 2011v6.3 2023 CoST packets.

The 2011v6.3 closure information is from a concatenation of previous facility and unit-level closure information used in the 2008 NEI-based emissions modeling platform used for 2007 air quality modeling. In addition, comments on the 2011v6.0 emissions modeling platform received by states and other agencies indicated that some previously specified closures should remain open. Ultimately, all data were updated to match the SMOKE FF10 inventory key fields, with all duplicates removed, and a single CoST packet was generated. The cumulative reductions in emissions for ptnonipm are shown in Table 4-12.

Table 4-12. Reductions from all facility/unit/stack-level closures for 2023en.

Pollutant	ptnonipm	pt_oilgas
CO	108,767	10,744
NH3	1,902	0
NOX	41,274	19,287
PM10	11,382	502
PM2.5	8,319	488
SO2	96,571	1,753
VOC	26,085	7,033

4.2.3 CoST PROJECTION Packets (afdust, ag, cmv, rail, nonpt, np_oilgas, ptnonipm, pt_oilgas, rwc)

As previously discussed, for point inventories, after application of any/all CLOSURE packet information, the next step in running a CoST control strategy is the application of all CoST PROJECTION packets. Regardless of inventory type (point or nonpoint), the PROJECTION packets applied prior to the CoST packets. For several emissions modeling sectors (i.e., afdust, ag, cmv, rail and rwc), there is only one CoST PROJECTION packet. For all other sectors, there are several different sources of PROJECTIONS data and, therefore, there are multiple PROJECTION packets that are concatenated and quality-assured for duplicates and applicability to the inventories in the CoST strategy. The PROJECTION (and CONTROL) packets were separated into a few "key" control program types to allow for quick summaries of these distinct control programs. The remainder of this section is broken out by CoST packet, with the exception of discussion of the various packets used for oil and gas and industrial source projections; these packets are a mix of different sources of data that targeted similar sources.

MARAMA provided PROJECTION and CONTROL packets for year 2023 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 states not covered by the MARAMA packets, projection factors for 2023 were generated by interpolating from the 2017 and 2025 packets, except for the nonpt and ptnonipm sectors that represent 2025 levels. The 2025 CoST packets are documented in the TSD Preparation of Emissions Inventories for the Version 6.2, 2011 Emissions Modeling Platform (USEPA, 2015b).

4.2.3.1 Paved and unpaved roads VMT growth (afdust)

<u>Packet:</u>

" PROJECTION_2011el_2023el_AFDUST_VMT_CPP_19sep2016_v0.txt"
"BETA_Projections_AFDUST_2023_21jul2016_emf_csv_02sep2016_v0.txt" (MARAMA)

These packets consist of county-level VMT projection factors for paved/unpaved roads and are based on county comparison of projected year 2023 VMT versus year 2011 VMT. The method for projecting VMT to year 2023 can be found in section 4.3.

We received comments from the 2018 NODA (search for 'EPA-HQ-OAR-2013-0809' at www.regulations.gov) suggesting we grow emissions from paved and unpaved road dust as a function of VMT. The resulting national sector-total increase from year 2011 to 2023 in $PM_{2.5}$ emissions are provided in Table 4-13. Note that this packet does not impact any other sources of fugitive dust emissions in the afdust sector (e.g., no impact on construction dust, mining and quarrying, etc.).

Table 4-13. Increase in total afdust $PM_{2.5}$ emissions from VMT projections

2011 Emissions	2023 Emissions	Percent Increase in 2023
2,510,246	2,753,900	9.71%

4.2.3.2 Livestock population growth (ag)

<u>Packet:</u>

"PROJECTION_2011_2023_ag_2011v6_2_no_RFS2_31aug2016_v0.txt"
"BETA_Projections_AG_2023_21jul2016" (MARAMA)

The EPA estimated animal population growth in NH_3 emissions from livestock in the ag sector. Except for dairy cows and turkey production, the animal projection factors are derived from national-level animal population projections from the USDA and the Food and Agriculture Policy and Research Institute (FAPRI). This methodology was initiated in 2005 for the 2005 NEI, but was updated on July 24, 2012, in support of the 2007v5 platform (EPA, 2012). For dairy cows, the EPA assumed that there would be no growth in emissions based on little change in U.S. dairy cow populations from years 2011 through 2023, according to linear regression analyses of the FAPRI projections. This assumption was based on an analysis of historical trends in the number of such animals compared to production rates. Although productions rates have increased, the number of animals has declined. Based on this analysis, the EPA concluded that production forecasts do not provide representative estimates of the future number of cows and turkeys; therefore, these forecasts were not used for estimating future-year emissions from these animals. In particular, the dairy cow population is projected to decrease in the future as it has for the past few decades; however, milk production will be increasing over the same period. Note that the NH_3 emissions from dairies are not directly related to animal population, but also nitrogen excretion. With the cow numbers going down and the production going up, the excretion value will change, but no change was assumed because a quantitative estimate was not available.

The national projection factors by animal category and ag sector total impacts are provided in Table 4-14, while the projection factors for MARAMA states varied by state. As discussed below, dairy cows are assumed to have no growth in animal population and, therefore, the projection factor for these animals is 1.0 (no growth). Impacts from the renewable fuels mandate are not included in projections for this sector. The overall average factor was 1.037 resulting in a 2.47% increase over 2011 and total emissions of 3,609,331 tons.

Table 4-14. NH_3 projection factors and total impacts to years 2023 for animal operations

Animal Category	Projection Factors
Dairy Cow	1.000
Beef	0.978
Pork	1.106
Broilers	1.119
Turkeys	0.927
Layers	1.087
Poultry Average	1.078

4.2.3.3 Locomotives and category 1, 2, & 3 commercial marine vessels (cmv, rail, ptnonipm, othpt)

Packets for rail, cmv and ptnonipm:

“PROJECTION_2011v6_3_2023_c1c2rail_BASE_02sep2016_v0.txt”
“PROJECTION_2011_2023_C3_CMV_ECA_IMO_2011v6_3_02sep2016_v0.txt”
“BETA_Projections_C1C2RAIL_2023_21jul2016_emf_csv_02sep2016_v0.txt” (MARAMA)

There are two components used to create projection factors for year 2023. The first component of the future year cmv and rail inventories is the non-California data projected from the 2011 base case. The second component is the CARB-supplied year 2011 and 2023 data for California.

For all states outside of California, national projection factors by SCC and pollutant between 2011 and future years reflect the May 2004 “Tier 4 emissions standards and fuel requirements” (https://nepis.epa.gov/Exe/ZyPDF.cgi/P100K5U2.PDF?Dockey=P100K5U2.PDF) as well as the March 2008 “Final locomotive-marine rule” controls (https://nepis.epa.gov/Exe/ZyPDF.cgi/P100094D.PDF?Dockey=P100094D.PDF). The future-year cmv and rail emissions account for increased fuel consumption based on Energy Information Administration (EIA) fuel consumption projections for freight, and emissions reductions resulting from emissions standards from the Final Locomotive-Marine rule (EPA, 2009d)[40]. For locomotives, the EPA applied HAP factors for VOC HAPs by using VOC projection factors to obtain 1,3-butadiene, acetaldehyde, acrolein, benzene, and formaldehyde. Similar to locomotives, C1/C2 VOC HAPs were projected based on the VOC factor. C1/C2 diesel emissions were projected based on the Final Locomotive Marine rule national-level factors. These non-California projection ratios are provided in Table 4-15. Note that projection factors for "…Yard Locomotives" (SCC=2285002010) are applied to the ptnonipm (point inventory) "yard locomotives" (SCC=28500201) reported by a couple of states in the 2011 NEI. Note that the factors for MARAMA states are similar to those below, but county-specific factors were provided for North Carolina and those are not reflected in the table.

Table 4-15. Non-California projection factors for locomotives and Category 1 and Category 2 CMV Emissions

SCC	Description	Poll	2023 Factor
2280002XXX	Marine Vessels, Commercial; Diesel; Underway & port emissions	CO	0.955
2280002XXX	Marine Vessels, Commercial; Diesel; Underway & port emissions	NO_X	0.603
2280002XXX	Marine Vessels, Commercial; Diesel; Underway & port emissions	PM	0.546
2280002XXX	Marine Vessels, Commercial; Diesel; Underway & port emissions	SO_2	0.091
2280002XXX	Marine Vessels, Commercial; Diesel; Underway & port emissions	VOC	0.596
2285002006	Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations	CO	1.212
2285002006	Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations	NO_X	0.676
2285002006	Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations	PM	0.522
2285002006	Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations	SO_2	0.035
2285002006	Railroad Equipment; Diesel; Line Haul Locomotives: Class I Operations	VOC	0.486
2285002007	Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations	CO	1.212
2285002007	Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations	NO_X	1.062
2285002007	Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations	PM	1.015
2285002007	Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations	SO_2	0.035
2285002007	Railroad Equipment; Diesel; Line Haul Locomotives: Class II / III Operations	VOC	1.212
2285002008	Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak)	CO	1.101
2285002008	Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak)	NO_X	0.519
2285002008	Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak)	PM	0.418
2285002008	Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak)	SO_2	0.032
2285002008	Railroad Equipment; Diesel; Line Haul Locomotives: Passenger Trains (Amtrak)	VOC	0.356
2285002009	Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines	CO	1.101
2285002009	Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines	NO_X	0.519
2285002009	Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines	PM	0.418
2285002009	Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines	SO_2	0.032
2285002009	Railroad Equipment; Diesel; Line Haul Locomotives: Commuter Lines	VOC	0.356
2285002010	Railroad Equipment; Diesel; Yard Locomotives	CO	1.212

[40] This rule lowered diesel sulfur content and tightened emission standards for existing and new locomotives and marine diesel emissions to lower future-year PM, SO_2, and NOx, and is documented at: http://www.epa.gov/otaq/marine.htm#2008final.

SCC	Description	Poll	2023 Factor
2285002010	Railroad Equipment; Diesel; Yard Locomotives	NO_X	0.873
2285002010	Railroad Equipment; Diesel; Yard Locomotives	PM	0.845
2285002010	Railroad Equipment; Diesel; Yard Locomotives	SO_2	0.035
2285002010	Railroad Equipment; Diesel; Yard Locomotives	VOC	0.812

For California projections, the CARB provided to the EPA the locomotive, and C1/C2 commercial marine emissions used to reflect years 2011 and 2023. These CARB inventories included nonroad rules reflected in the December 2010 Rulemaking Inventory (http://www.arb.ca.gov/regact/2010/offroadlsi10/offroadisor.pdf), those in the March 2011 Rule Inventory, the Off-Road Construction Rule Inventory for "In-Use Diesel," cargo handling equipment rules in place as of 2011 (see http://www.arb.ca.gov/ports/cargo/cargo.htm), and the 2007 and 2010 regulations to reduce emissions diesel engines on commercial harbor craft operated within California waters and 24 nautical miles (nm) of the California baseline.

The California C1/C2 CMV and locomotive year-specific 2023 emissions were obtained from the CARB in the form of Excel workbooks. These data were converted to SMOKE FF10 format. These emissions were developed using Version 1 of the CEPAM, which supports various California off-road regulations. Documentation of the CARB off-road methodology, including cmv and rail sector data, is provided here: http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles.

The non-California projection factors were applied to all "offshore" C1 and C2 CMV emissions. These offshore emissions, in the 2011 NEI, start at the end of state waters and extend out to the EEZ. A summary of the national impact for the U.S. (including California) and rail and offshore C1 &C2 cmv sector emissions are provided in Table 4-16.

Table 4-16. Difference in Category 1& 2 cmv and rail sector emissions between 2011en and 2023en

Region	Pollutant	2011	2023	Difference 2023 – 2011
U.S. CMV	CO	70,408	76,265	5,857
U.S. CMV	NO_X	413,314	280,626	-132,688
U.S. CMV	PM_{10}	19,629	7,513	-12,116
U.S. CMV	$PM_{2.5}$	18,099	7,039	-11,060
U.S. CMV	SO_2	91,045	6,811	-84,234
U.S. CMV	VOC	12,578	12,880	302
Offshore CMV	CO	66,395	63,421	-2,974
Offshore CMV	NO_X	326,631	197,021	-129,610
Offshore CMV	PM_{10}	10,795	5,894	-4,901
Offshore CMV	$PM_{2.5}$	10,471	5,717	-4,754
Offshore CMV	SO_2	4,014	366	-3,648
Offshore CMV	VOC	7,472	4,453	-3,019
U.S. rail	CO	122,703	145,627	22,924
U.S. rail	NO_X	791,381	563,382	-227,999
U.S. rail	PM_{10}	25,898	14,236	-11,662
U.S. rail	$PM_{2.5}$	23,963	13,165	-10,798

U.S. rail	SO_2	7,936	340	-7,596
U.S. rail	VOC	40,851	21,384	-19,467

As discussed in Section 2.4.1 of the 2011v6.3 platform TSD, the EPA estimates for C3 CMV, emissions data were developed for year 2002 and projected to year 2011 for the 2011 base case, and used where states did not submit data to Version 2 of the 2011 NEI. Pollutant and geographic-specific projection factors to year 2011 were applied, along with projection factors to years 2023 that reflect assumed growth and final ECA-IMO controls. These emissions estimates reflect the EPA's coordinated strategy for large marine vessels. More information on the EPA's coordinated strategy for large marine vessels can be found in our Category 3 Marine Diesel Engines and Fuels regulation published in April 2010. That rule, as well as information about the North American and U.S. Caribbean Sea ECAs, designated by amendment to MARPOL Annex VI, can be found at: https://www.epa.gov/regulations-emissions-vehicles-and-engines/international-standards-reduce-emissions-marine-diesel.

Projection factors for creating the year 2023 cmv inventory from the 2011 base case are provided in Table 4-17. For more information on the mapping of the states to each EEZ, see Section 2.4.1 of the 2011v6.3 platform TSD. For example, Washington state emissions are grown the same as all North Pacific offshore emissions.

Table 4-17. Growth factors to project the 2011 ECA-IMO inventory to 2023

Region	**EEZ (offshore) FIPS**	**CO**	**NO_X**	**PM_{10}**	**PM_{25}**	**SO_2**	**VOC**
North Pacific (NP)	85001	1.49	0.85	0.2	0.2	0.06	1.49
South Pacific (SP)	85002	1.86	0.95	0.26	0.26	0.07	1.86
East Coast (EC)	85004	1.71	0.89	0.23	0.23	0.06	1.71
Gulf Coast (GC)	85003	1.42	0.75	0.19	0.19	0.05	1.42
Great Lakes (GL)	n/a	1.23	0.95	0.16	0.16	0.04	1.23
Outside ECA	98001	1.72	1.39	0.63	0.63	0.58	1.72

Packet for othpt:

"PROJECTION_2011_2023_C3_CMV_ECA_IMO_2011v6_3_02sep2016_v0.txt"

Note that the MARAMA packet provided in BETA_Projections_C3Marine_2023_20feb2016_emf_csv_02sep2016_v0.txt was not used because the offshore emissions were not in a MARAMA state. As discussed in Section 2.4.2 of the 2011v6.3 platform TSD, emissions outside the 3 to 10-mile coastal boundary, but within the approximately 200 nm EEZ boundaries, were projected to year 2023 using the same regional adjustment factors as the U.S. emissions; however, the FIPS codes were assigned as "EEZ" FIPS and these emissions are processed in the "othpt" sector. Note that state boundaries in the Great Lakes are an exception, extending through the middle of each lake such that all emissions in the Great Lakes are assigned to a U.S. county or Ontario. The classification of emissions to U.S. and Canadian FIPS codes is needed to avoid double-counting of Canadian-provided C3 CMV emissions in the Great Lakes.

The cumulative impact of these ECA-IMO projections and controls to the U.S. + near-offshore (cmv sector) and far-offshore emissions (othpt sector) in 2023 is provided in Table 4-18.

Table 4-18. Difference in Category 3 cmv sector and othpt C3 CMV emissions between 2011 and 2023

Region	Pollutant	2011 emissions	2023 emissions	Difference 2023 - 2011
Offshore to EEZ*	CO	133,574	173,938	40,364
Offshore to EEZ*	NOX	798,258	728,724	-69,534
Offshore to EEZ*	PM10	28,451	6,854	-21,597
Offshore to EEZ*	PM2_5	26,113	6,293	-19,820
Offshore to EEZ*	SO2	222,113	16,509	-205,604
Offshore to EEZ*	VOC***	81,593	98,753	17,160
Non-US SECA C3	CO	187,439	321,978	134,539
Non-US SECA C3	NOX	2,209,800	3,078,374	868,574
Non-US SECA C3	PM10	187,587	118,375	-69,212
Non-US SECA C3	PM2_5	172,580	108,413	-64,167
Non-US SECA C3	SO2	1,391,702	803,736	-587,966
Non-US SECA C3	VOC***	79,575	136,692	57,117

* - Offshore to EEZ includes both c3marine, and the offshore oil rigs/etc from the US point inventory
*** - INCLUDES pre-speciated inventory VOC in Canada, so post-SMOKE VOC_INV < VOC

4.2.3.4 Upstream distribution, pipelines and refineries (nonpt, ptnonipm, pt_oilgas)

Packet:

ptnonpim and nonpt sectors only:
"PROJECTION_2011_2025_OTAQ_upstream_GasDist_pipelines_refineries_2011v6_2_05feb2015_05feb2015_v0.txt"
pt_oilgas sector only: "PROJECTION_2011v6_2025_pipelines_refineries
"BETA_Projections_OTAQ_Upstream_GasDist_2023_20feb2016_emf_csv_02sep2016_v0.txt" (MARAMA)

To account for projected increases in renewable fuel volumes due to the Renewable Fuel Standards (RFS2)/EISA (EPA, 2010a) and decreased gasoline volumes due to RFS2 and light-duty greenhouse gas standards as quantified in AEO 2014 (http://www.eia.gov/forecasts/archive/aeo14/), the EPA developed county-level inventory adjustments for gasoline and gasoline/ethanol blend transport and distribution. Here, for non-MARAMA states, year 2025 factors are used for year 2023. MARAMA provided year 2023-specific factors. These adjustments account for losses during truck, rail and waterways loading/unloading and intermodal transfers such as highway-to-rail, highways-to-waterways, and all other possible combinations of transfers. Adjustments for 2018 only account for impacts of RFS2, and the 2025 adjustments also account for additional impacts of greenhouse gas emission standards for motor vehicles (EPA, 2012b) on transported volumes. These emissions are entirely evaporative and, therefore, limited to VOC.

A 2018 inventory that included impacts of the EISA mandate was developed by applying adjustment factors to the 2011NEIv2 inventory. These adjustments were made using an updated version of the EPA's model for upstream emission impacts, developed for the RFS2 rule[41]. The methodology used to make these adjustments is described in a 2014 memorandum included in the docket for the EPA Tier 3 rule (EPA, 2014)[42].

[41] U.S. EPA. 2013. Spreadsheet "upstream_emissions_rev T3.xls.

[42] U. S. EPA. Development of Air Quality Reference Case Upstream and Portable Fuel Container Inventories for the Tier 3 Final Rule. Memorandum from Rich Cook, Margaret Zawacki and Zoltan Jung to the Docket. February 25, 2014. Docket EPA-HQ-OAR-2011-0135.

Ethanol emissions were estimated in SMOKE by applying the ethanol to VOC ratios from headspace profiles to VOC emissions for E10 and E15, and an evaporative emissions profile for E85. These ratios are 0.065 for E10, 0.272 for E15, and 0.61 for E85. The E10 and E15 profiles were obtained from an ORD analysis of fuel samples from EPAct exhaust test program[43] and were submitted for incorporation into the EPA's SPECIATE database. The E85 profile was obtained from data collected as part of the CRC E-80 test program (Environ, 2008) and was also submitted into the EPA's SPECIATE database. For more details on the change in speciation profiles between the base and future years, see Section 3.2 of the 2011v6.3 platform TSD.

Pipeline usage and refinery emissions were adjusted to account for impacts of the 2017-2025 light duty vehicle greenhouse gas emission standards, as well as renewable fuel volume projections. These adjustments were developed by the EPA's OTAQ and impact processes such as process heaters, catalytic cracking units, blowdown systems, wastewater treatment, condensers, cooling towers, flares and fugitive emissions. Calculation of the emission inventory impacts of decreased gasoline and diesel production, due to renewable fuel volume projections, on nationwide refinery emissions was done in the EPA's spreadsheet model for upstream emission impacts (EPA, 2009b). Emission inventory changes reflecting these impacts were used to develop adjustment factors that were applied to inventories for each petroleum refinery in the U.S. These impacts of decreased production were assumed to be spread evenly across all U.S. refineries. Toxic emissions were estimated in SMOKE by applying speciation to VOC emissions. It should be noted that the adjustment factors are estimated relative to that portion of refinery emissions associated with gasoline and diesel fuel production. Production of jet fuel, still gas and other products also produce emissions. If these emissions were included, the adjustment factors would not be as large.

The resulting adjustments for pipelines, refineries and the gasoline distribution processes (RBT, BPS and BTP) are provided in Table 4-19. Separate adjustments were applied to refinery to bulk terminal (RBT), bulk plant storage (BPS), and bulk terminal to gasoline dispensing pump (BTP) components. Emissions for the BTP component are greater than the RBT and BPS components. An additional adjustment was applied for 2025 at a national scale to account for impacts of gasoline volume reductions of the 2017-2025 light-duty greenhouse gas rule.

Notice that the "2011 Emissions" are not the same in Table 4-19. This is because these "2011" emissions are actually an intermediate set up projections applied after a first CoST strategy used to apply most other PROJECTION and CONTROL packets. We decided to first apply these other packets because we have multiple PROJECTION and CONTROL programs that impact the same emission sources. For this example, we applied year-specific industrial sector AEO-based growth (discussed in the next section) with our first CoST strategy, then applied these "EISA" adjustments on the results of this first CoST strategy. Similarly, we have RICE existing NESHAP, as well as NSPS, controls that need to be applied in separate strategies. Alternatively, we could have made "compound" CoST packets that combine these PROJECTION (and CONTROL) factors, but preferred to keep these packets separate for transparency. If we tried to process the multiple packets affecting the same sources in a single CoST strategy, CoST would either fail if the packet entries were the same key-field resolution (duplicate error), or, if packets were at a different key-field resolution, CoST would only apply the packet entry with higher priority according to Table 4-10.

Table 4-19. Petroleum pipelines & refineries and production storage and transport factors and reductions

Poll	Year	Factors		Reduction	

[43] U.S. EPA. 2011. Hydrocarbon Composition of Gasoline Vapor Emissions from Enclosed Fuel Tanks. Office of Research and Development and Office of Transportation and Air Quality. Report No. EPA-420-R-11-018. EPA Docket EPA-HQ-OAR-2011-0135.

		Pipelines & Refineries	RBT	BTP/BPS	2011 Emissions		Percent Reduction
CO	2023	0.9445	n/a	n/a	53,501	2,969	5.55%
NOX	2023	0.9348	n/a	n/a	68,354	4,454	6.52%
PM10	2023	0.9668	n/a	n/a	24,484	813	3.32%
PM2.5	2023	0.9679	n/a	n/a	21,599	694	3.21%
SO2	2023	0.9517	n/a	n/a	78,944	3,815	4.83%
VOC	2023	0.9650	n/a	n/a	750,025	26,266	3.50%

4.2.3.5 Oil and gas and industrial source growth (nonpt, np_oilgas, ptnonipm, pt_oilgas)

Packets:

ptnonipm and nonpt sectors:
"PROJECTION_2011v6_2_2025_SCC_POINT_LADCO_09dec2014_09dec2014_v0.txt"
"PROJECTION_2011v6_2_2025_NAICS_SCC_SCA_orig_NEI_matched_CAPPED2_5_04dec2014_04dec2014_v0.txt"
"PROJECTION_2011v6_2_2025_SCC_POINT_SCA_orig_CAPPED_09dec2014_04feb2015_v1.txt"
"PROJECTION_2011v6_2_2025_SRAcapped_POINT_05dec2014_05dec2014_v0.txt"
'PROJECTION_TCEQ_ptnonipm_NAICS_comments_2011v6_2025_revised_16jul2015_v0.txt"
"PROJECTION_2011v6_2_2025_SCC_NONPOINT_LADCO_09dec2014_09dec2014_v0.txt"
"PROJECTION_2011v6_2_2025_SCC_NONPOINT_SCA_orig_CAPPED_09dec2014_09dec2014_v0.txt"
"PROJECTION_2011v6_2_2025_nonpoint_SCC_SRAcapped_05dec2014_05dec2014_v0.txt"
"PROJECTION_2011_2025_aircraft_ST_and_by_airport_22jan2015"
"PROJECTION_VA_ME_TCEQ_AL_comments_2011v6_2019_04dec2013_v0.txt"
"PROJECTION_2011v6_3__2017_Oklahoma_source_NODA_11jan2016_v1.txt"
"PROJECTION_2011v6_2_2025_TCEQ_v6_leftovers_NONPOINT_30jan2015_30jan2015_v0.txt"

np_oilgas sectors:
np_oilgas_offshore_coalbed_2011_2023en_projection_packet_03aug2017_v0.txt
np_oilgas_TCEQ_2014_2023_projection_packet_03aug2017_v0.txt
np_oilgas_2011_2023en_projection_packet_03aug2017_v0.txt
pt_oilgas sector:
OK_pt_oil_gas_projection_csv_06jan2016_v0.txt
PROJECTION_2011_2023_NAICS_SCC_SCA_orig_NEI_matched_CAPPED2_5_csv_04oct2016_v1.txt
PROJECTION_2011v6_2_2023_SCC_POINT_LADCO_csv_04oct2016_v0.txt
PROJECTION_2011v6_2_2023_SCC_POINT_SCA_orig_CAPPED_09dec2014_04oct2016_v0.txt
PROJECTION_2011v6_2_2023_SRAcapped_POINT_05dec2014_04oct2016_v0.txt
PROJECTION_TCEQ_ptnonipm_NAICS_comments_2011v6_2023_04dec2013_04oct2016_v0.txt
pt_oilgas_2011_2023en_projection_packet_03aug2017_v0.txt
PROJECTION_2011v6_2025_pipelines_refineries_26mar2014_v0.txt

MARAMA states: "BETA_Projections_NP_OILGAS_2023_22apr2016_emf.csv" (MARAMA: PA only)
"BETA_Projections_PT_OILGAS_2023_24aug2016_emf.csv" (MARAMA: PA only)
"BETA_Projections_PT_NonERTAC_2023_24aug2016_emf.csv" (MARAMA)
"BETA_Projections_PT_Small_EGU_2023_25jul2016_emf.csv" (MARAMA)
"BETA_Projections_NonPoint_2023_2016_08_24_emf.csv" (MARAMA)
"BETA_Projections_NONPT_REFUELING_2023_25jul2016_emf.csv" (MARAMA)
"BETA_Projections_Aircraft_Engine_GSE_APU_2023_10aug2016_emf.csv" (MARAMA)

The EPA provided a NODA (search for the docket 'EPA-HQ-OAR-2013-0809' on *regulations.gov*) for the 2011v6.0 emissions modeling platform and projected 2018 inventory in January, 2014. A significant number of the comments were about the EPA's "no growth" assumption for industrial stationary sources and about the current projection approach for oil and gas sources that was applied similarly to five broad geographic (NEMS) regions and limited to only oil and gas drilling activities.

With limited exceptions, the EPA used a no-growth assumption for all industrial non-EGU emissions since the 2005 NEI-based emissions modeling platform (EPA, 2006). However, comments provided to the EPA for this platform (via the NODA) and for previous modeling platforms suggested that this approach was insufficient. In addition, the NO_x Budget program, which had a direct impact on post-2002 emissions reductions, is in full compliance in the 2011 NEI. This means that additional large-scale industrial reductions should not be expected beyond 2011 in the absence of on-the-books state and federal rules.

In response to the comments about the EPA's no-growth and previous approaches, the EPA developed industrial sector activity-based growth factors. In response to the NODA, many states have additionally provided detailed activity-based projection factors for industrial sources, including oil and gas sources. To develop the methods described here, we have blended the state-provided growth factors with the EPA-developed industrial sector growth factors. This approach has attempted to balance using the specific information that is available with the EPA's interest in consistency for a given sector and technical credibility. Table 4-14 lists the new resulting data sources for industrial sector non-EGU growth factors that the EPA applied to estimate year 2023 emissions for this emissions modeling platform. Ultimately, there were three broad sources of projection information for industrial sources, including oil and gas; these sources are referenced as the following for simplicity:

1) EPA:
   a. **(NEW)** Reflects EPA-generated factors based on EIA state historical production data and AEO2017 reference case production data (label dated "03aug2017").
   b. Reflects EPA-sponsored data provided by a contractor (SC&A, 2014a; SC&A, 2014b). Packet file names for these data include "SCA."
2) MARAMA:
   a. Reflects data submitted on behalf of Atlantic seaboard states from North Carolina through Maine, and extending west through Pennsylvania and West Virginia. Packet file names for these data include "SRA" (SRA, 2014).
   b. Reflects data submitted on behalf of Atlantic seaboard states from North Carolina through Maine, and extending west through Pennsylvania and West Virginia. Packet file names that begin with "BETA" (MARAMA, 2016).
3) LADCO: Reflects data submitted on behalf of Lake Michigan Air Directors Consortium (LADCO) states (MN, WI, MI, IL, IN, OH). Projection data from this data source are reflected in packet names containing "LADCO" (Alpine Geophysics, 2014).

Table 4-20. Sources of new industrial source growth factor data for year 2023 in the 2011v6.3 platform

Abbrev.	Source	Geographic Resolution	Inventory Resolution	Use/Caveat
MARAMA "BETA" packets	MARAMA/states using 2015 AEO data and other data sources	State or county for nonpoint and facility and below for most point sources	Facility and sub-facility for point, SCC-level for nonpoint	Provided by MARAMA (2016) for year-2023 specific projection purposes.

Abbrev.	Source	Geographic Resolution	Inventory Resolution	Use/Caveat
EPA New projection packets for 2023en case: “np_oilgas_offshore_coalbed_2011_2023en_projection_packet_03aug2017_v0.txt” “np_oilgas_TCEQ_2014_2023_projection_packet_03aug2017_v0.txt” “np_oilgas_2011_2023en_projection_packet_03aug2017_v0.txt” “pt_oilgas_2011_2023en_projection_packet_03aug2017_v0.txt”	Non-MARAMA states using EIA historical production state data and 2017 AEO Crude Oil Production and Natural Gas Production data	EIA Supply Region	State or county/ SCC	Impacts both point and nonpoint oil and gas sectors as well as some non-EGU point sources not in the pt_oilgas sector.

Table 4-20 above lists only the new projection packets used to estimate year 2023 emissions for this modeling effort. MARAMA provided year-2023 specific factors for all sectors mentioned in this section. The EPA generated factors using AEO2017 data were also year-2023 specific emissions. The previous TSDs for 2011v6.2 and 2011v6.3 describe the other packets mentioned earlier in this section. Specifically, year 2025 packets mentioned in this section are described in the 2011v6.2 TSD (EPA, 2015b).

Natural Gas Consumption and Crude Oil Production

In the 2023el case, the AEO 2016 reference case data (http://www.eia.gov/outlooks/aeo/tables_ref.cfm) was used to project production-related oil and gas sources. The AEO2016 tables used include the National Oil and Gas Supply Table #14, Lower 48 Crude Oil Production Table #60, and Lower 48 Natural Gas Production Table #61. These AEO2016 tables were used to project emissions related to oil and gas production for the six EIA Supply Regions (Figure 4-1) plus offshore regions. These projection factors were applied to appropriate production related SCCs in the NEI2011v2 inventory. In cases where a SCC description listed both oil and gas production processes may be involved, an average projection factor was used for that EIA Supply Region. For more details on the 2023el case approach, see the *Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the year 2023* technical support document (EPA, 2016b).

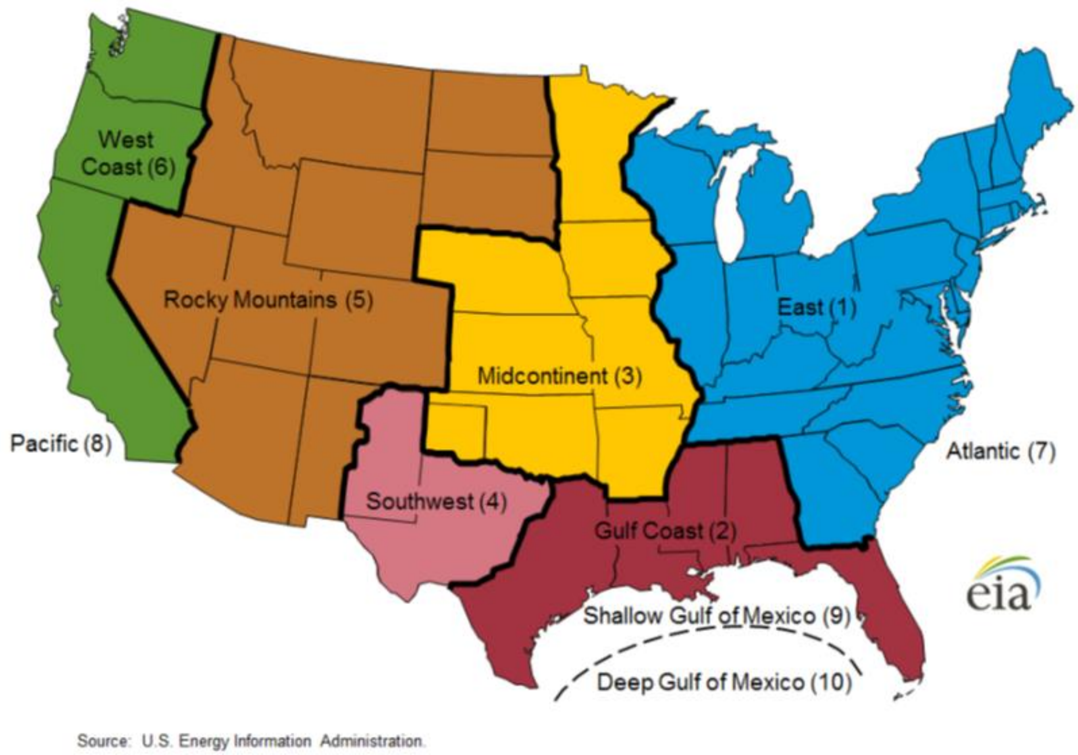
The method used in the 2023el case was released in a Notice of Data Availability (NODA), (82 FR 1733, Docket No. EPA-HQ-OAR-2016-0751). Comments on the methodology were solicited with the NODA. Some states and other stakeholders recommended future methodology updates for oil and gas projections. In particular, some commenters expressed strong interest in enhancing the methodology to better account for how states in a given multi-state region can have notably different trends in oil and gas production. In response to these comments, EPA updated the projection method in the 2023en case for production-related oil and gas emission sources to better account for differences in both historical and projected state oil and gas production trends.

In the 2023en case, updated state-specific 2011-2023 projection factors were generated and applied. The projection factors used in the 2023en case are the products of multiplying historic (2011-2015) state-level factors by regional projection factors that represent 2015 to 2023.

- The 2011-2015 factors are based on historic state oil and gas production data published by EIA.
    - Crude oil production data
        - http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm

- o Dry natural gas estimated production data
  - http://www.eia.gov/dnav/ng/ng_sum_lsum_a_epg0_r20_bcf_a.htm
- The 2015-2023 factors are based on projected oil and gas production in EIA's 2017 Annual Energy Outlook (AEO) Reference Case without the Clean Power Plan for the six EIA Supply Regions (Figure 4-1)

Figure 4-1. Oil and Gas NEMS Regions



To better differentiate state trends within each region, the following three assumptions were implemented which cause the projection factors to vary based on historic oil and gas production:

1. States without EIA oil and gas production data for 2011-2015 have their factor set to 1.0 for 2011-2015; a factor of 1.0 indicates that there is no growth from 2011-2015.
2. States without EIA oil and gas production data for 2011-2015 have 2015-2023 projection factors set to 1.0, unless the region containing the state has a 2015-2023 factor less than 1.0, in which case the lower regional factor will be applied.
3. If a state has a 2011-2015 projection factor less than 1.0 and its associated 2015-2023 regional factor is greater than 1.0, then the 2015-2023 factor is set to 1.0.

There were some states for which the approach had to be somewhat modified for various reasons. For example, in New Mexico which has counties falling into two different EIA Supply Regions in the 2017 AEO data, the 2011-2015 factors are state-specific and the 2015-2023 factors are region-specific. For Texas, which has counties falling into three different EIA Supply Regions in the 2017 AEO data, a 2014 emissions inventory provided in response to the NODA was paired with 2014-2023 projection factors that are region-specific. For Pennsylvania, the 2023el projection factors for the np_oilgas sector were used in the 2023en case. The net impacts of these projection factors for each of the modeling sectors is provided in Table 4-21. Specific projection factors for each state are available on the Projection Factors tab of the spreadseheet *2011_2023en_oil_gas_projections_082517.xlsx* available with the reports for the 2011v6.3 platform area of the FTP site: ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/reports/2011en_and_2023en/.

Table 4-21. Industrial source projections net impacts for 2023en

Pollutant	Sector	2011 Emissions Subject to projection	Intermediate Projected Emissions	Difference (Future - 2011)	% Difference (Future - 2011)
CO	nonpt	733,239	790,635	57,396	8%
CO	np_oilgas	669,611	861,154	191,544	29%
CO	pt_oilgas	235,236	290,468	55,232	23%
CO	ptnonipm	1,028,175	1,152,841	124,666	12%
CO	**Total**	**2,666,261**	**3,095,098**	**428,837**	**16%**
NH_3	nonpt	18,381	18,830	449	2%
NH_3	pt_oilgas	266	237	-29	-11%
NH_3	ptnonipm	12,645	13,473	828	7%
NH_3	**Total**	**31,291**	**32,540**	**1,248**	**4%**
NO_X	nonpt	499,419	517,606	18,187	4%
NO_X	np_oilgas	707,212	942,919	235,707	33%
NO_X	pt_oilgas	541,483	592,903	51,419	9%
NO_X	ptnonipm	713,372	799,033	85,662	12%
NO_X	**Total**	**2,461,486**	**2,852,461**	**390,975**	**16%**
PM_{10}	nonpt	280,933	315,788	34,856	12%
PM_{10}	np_oilgas	18,082	24,783	6,702	37%
PM_{10}	pt_oilgas	15,101	16,500	1,399	9%
PM_{10}	ptnonipm	140,965	159,778	18,812	13%
PM_{10}	**Total**	**455,081**	**516,849**	**61,768**	**14%**
$PM_{2.5}$	nonpt	224,860	254,129	29,268	13%
$PM_{2.5}$	np_oilgas	16,618	21,789	5,171	31%
$PM_{2.5}$	pt_oilgas	14,790	16,159	1,369	9%
$PM_{2.5}$	ptnonipm	114,104	130,535	16,431	14%
$PM_{2.5}$	**Total**	**370,372**	**422,612**	**52,239**	**14%**
SO_2	nonpt	253,885	237,039	-16,846	-7%
SO_2	np_oilgas	29,058	48,014	18,956	65%
SO_2	pt_oilgas	59,322	59,264	-58	0%
SO_2	ptnonipm	481,022	482,098	1,076	0%
SO_2	**Total**	**823,287**	**826,415**	**3,128**	**0%**
VOC	nonpt	1,133,960	1,189,481	55,520	5%
VOC	np_oilgas	2,563,018	3,849,332	1,286,314	50%

Pollutant	Sector	2011 Emissions Subject to projection	Intermediate Projected Emissions	Difference (Future - 2011)	% Difference (Future - 2011)
VOC	pt_oilgas	146,969	175,377	28,408	19%
VOC	ptnonipm	177,442	203,905	26,463	15%
VOC	**Total**	**4,021,389**	**5,418,095**	**1,396,706**	**35%**

4.2.3.6 Aircraft (ptnonipm)

Packet:

"PROJECTION_2011_2025_aircraft_ST_and_by_airport_22jan2015_v0.txt"
"BETA_Projections_Aircraft_Engine_GSE_APU_2023_10aug2016_emf.csv" (MARAMA)

Aircraft emissions are contained in the ptnonipm inventory. These 2011 point-source emissions are projected to future years by applying activity growth using data on ITN operations at airports. The ITN operations are defined as aircraft take-offs whereby the aircraft leaves the airport vicinity and lands at another airport, or aircraft landings whereby the aircraft has arrived from outside the airport vicinity. The EPA used projected ITN information available from the Federal Aviation Administration's (FAA) Terminal Area Forecast (TAF) System: https://www.faa.gov/data_research/aviation/taf/ (publication date March, 2014). This information is available for approximately 3,300 individual airports, for all years up to 2040. The methods that the FAA used for developing the ITN data in the TAF are documented in: http://www.faa.gov/about/office_org/headquarters_offices/apl/aviation_forecasts/taf_reports/media/TAF_Summary_Report_FY2013-2040.pdf.

None of our aircraft emission projections account for any control programs. The EPA considered the NOx standard adopted by the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP) in February 2004, which is expected to reduce NOx by approximately 3 percent by 2020. However, this rule has not yet been adopted as an EPA (or U.S.) rule and, therefore, its effects were not included in the future-year emissions projections.

The EPA developed two sets of projection factors for aircraft. The first set was a simple state-level aggregation, used primarily for airports with very little activity, by ITN operation type (commercial, general aviation, military and air taxi) to be used as a default method for projecting from 2011 to future years. The second set of projection factors was by airport, where the EPA projects emissions for each individual airport with significant ITN activity.

Where NEI facility identifiers were not matched to FAA airport identifiers, we simply summed the ITN operations to state totals by year and aircraft operation and computed projection factors as future-year ITN to year-2011 ITN. The EPA assigned factors to inventory SCCs based on the operation type shown in Table 4-22.

Table 4-22. NEI SCC to FAA TAF ITN aircraft categories used for aircraft projections

SCC	Description	FAA ITN Type
2265008005	Commercial Aircraft: 4-stroke Airport Ground Support Equipment	Commercial
2267008005	Commercial Aircraft: LPG Airport Ground Support Equipment	Commercial
2268008005	Commercial Aircraft: CNG Airport Ground Support Equipment	Commercial

SCC	Description	FAA ITN Type
2270008005	Commercial Aircraft: Diesel Airport Ground Support Equipment	Commercial
2275000000	All Aircraft Types and Operations	Commercial
2275001000	Military Aircraft, Total	Military
2275020000	Commercial Aviation, Total	Commercial
2275050011	General Aviation, Piston	General
2275050012	General Aviation, Turbine	General
2275060011	Air Taxi, Total: Air Taxi, Piston	Air Taxi
2275060012	Air Taxi, Total: Air Taxi, Turbine	Air Taxi
2275070000	Commercial Aircraft: Aircraft Auxiliary Power Units, Total	Commercial
27501015	Internal Combustion Engines; Fixed Wing Aircraft L & TO Exhaust; Military; Jet Engine: JP-5	Military
27502011	Internal Combustion Engines; Fixed Wing Aircraft L & TO Exhaust; Commercial; Jet Engine: Jet A	Commercial
27505001	Internal Combustion Engines; Fixed Wing Aircraft L & TO Exhaust; Civil; Piston Engine: Aviation Gas	General
27505011	Internal Combustion Engines; Fixed Wing Aircraft L & TO Exhaust; Civil; Jet Engine: Jet A	General

Most NEI airports matched FAA TAF identifiers and, therefore, use airport-specific projection factors. We applied a cap on projection factors of 2.0 (100 percent increase) for state-level defaults and 5.0 for airport-specific entries. None of the largest airports/larger-emitters had projection factors close to these caps. A national summary of aircraft emissions between 2011 and future year 2023 are provided in Table 4-23.

Table 4-23. National aircraft emission projection summary for 2023en

	Emissions		Difference	% Difference
	2011	**2025**	**2025-2011**	**2025**
CO	489,854	559,783	69,930	14.28%
NO_X	120,968	157,610	36,642	30.29%
PM_{10}	9,164	10,039	874	9.54%
$PM_{2.5}$	7,891	8,709	818	10.37%
SO_2	14,207	18,139	3,932	27.67%
VOC	32,023	38,077	6,054	18.90%

4.2.3.7 Cement manufacturing (ptnonipm)

Packet:

“PROJECTION_2011_2025_ISIS_cement_by_CENSUS_DIVISION.txt”

As indicated in Table 4-1, the Industrial Sectors Modeling Platform (ISMP) (EPA, 2010b) was used to project the cement industry component of the ptnonipm emissions modeling sector to 2025; we used year 2025 emissions for year 2023. This approach provided reductions of criteria and select hazardous air pollutants. The

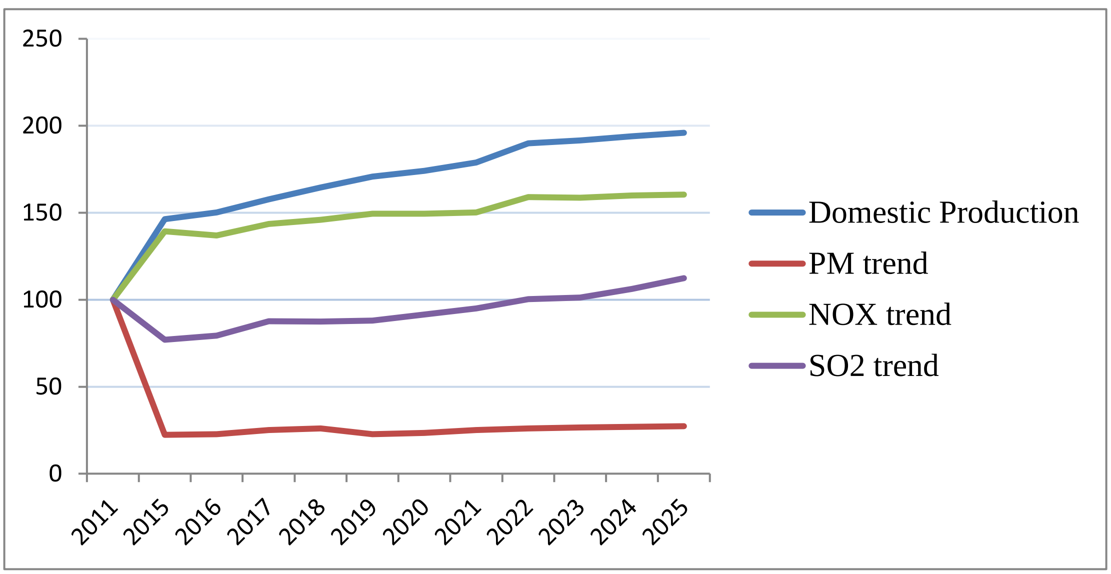
ISMP cement emissions were developed in support for the Portland Cement NESHAPs and the NSPS for the Portland cement manufacturing industry.

The ISMP model produced a Portland Cement NESHAP policy case of multi-pollutant emissions for individual cement kilns (emission inventory units) that were relevant for years 2015 through 2030. These ISMP-based emissions are reflected using a CoST packet for all existing kilns that are not impacted by more local information from states (or consent decrees). ISMP also generates new cement kilns that are permitted (point inventory) and not-permitted, but generated based on ISMP assumptions on demand and infrastructure (nonpt inventory). These new cement kilns are discussed in Section 4.2.5.4.

The PROJECTION packets contain U.S. census division level based projection factors for each NEI unit (kiln) based on ISMP updated policy case emissions at existing cement kilns. The units that closed before 2025 are included in the 2025 base case but are included in other CoST packets that reflect state comments and consent decrees (discussed in Section 4.2.4.11).

The ISMP model, version August 2013, was used for these projections. Recent data updates include updated matching of kilns to better capture recent retirements, capacity additions and projections of capacity additions from Portland Cement Association (PCA) Plant Information Summary of December 31, 2010, and feedback from Portland Cement NESHAP reconsideration comments. Updated cement consumption projections are based on a post-recession (July 2012) PCA long-term cement consumption outlook. Updated emissions controls in 2015 from the NESHAP are also reflected. Overall, as seen in Figure 4-2, domestic production of cement grows significantly between 2011 and 2015, then more slowly through 2018. Meanwhile, emissions from NESHAP-regulated pollutants such as PM and SO_2 drop significantly based on regulated emissions rates. Emissions for NOx increase, though not as much as production because the ISMP model continues the recent trend in the cement sector of the replacement of lower capacity, inefficient wet and long dry kilns with bigger and more efficient preheater and precalciner kilns.

Figure 4-2. Cement sector trends in domestic production versus normalized emissions



Multiple regulatory requirements such as the NESHAP and NSPS currently apply to the cement industry to reduce CAP and HAP emissions. Additionally, state and local regulatory requirements might apply to individual cement facilities depending on their locations relative to ozone and $PM_{2.5}$ nonattainment areas. The ISMP model provides the emission reduction strategy that balances: 1) optimal (least cost) industry operation;

2) cost-effective controls to meet the demand for cement; and 3) emission reduction requirements over the time period of interest.

The first step in using ISMP 2025 projected emissions is matching the kilns in future years to those in the 2011 NEI. While ISMP provides by-kiln emissions for each future year, the EPA cement kilns experts preferred that the agency project existing cement kilns based on a more-smooth geographic approach to reduce the "on/off" switching that ISMP assigns to each kiln based on production and capacity demands. It would be inefficient and unrealistic to project existing cement kilns to operate as essentially 0 percent or 100 percent capacity based strictly on ISMP output. Therefore, the EPA developed a U.S. Census Division approach where ISMP emissions in 2011 and future years, that matched the 2011 NEI (e.g., not new ISMP kilns), were aggregated by pollutant for each year within each of the nine census divisions in the contiguous U.S. (http://www.eia.gov/consumption/commercial/images/cendivco.gif). These aggregate emissions were used to create 2025/2011 emissions ratios for each pollutant and geographic area. The projection ratios, provided in Table 4-24, were then applied to all 2011 NEI cement kilns, except for kilns where specific local information (e.g., consent decrees/settlements/local information) was available.

Table 4-24. U.S. Census Division ISMP-based projection factors for existing kilns

Region	Division	NOx	PM	SO_2	VOC
		2025	2025	2025	2025
Midwest	East North Central	2.053	0.144	3.034	0.67
Midwest	West North Central	1.279	0.673	1.262	0.492
Northeast	Middle Atlantic	1.221	0.119	0.867	0.569
Northeast	New England	2.56	0.004	3.563	0.713
South	East South Central	0.999	0.109	0.402	0.323
South	South Atlantic	1.077	0.339	0.936	0.42
South	West South Central	1.526	0.174	0.664	0.252
West	Mountain	1.321	1.032	1.366	0.345
West	Pacific	1.465	0.006	0.251	0.29

Table 4-25 shows the magnitude of the ISMP census division based projected cement industry emissions at existing NEI facilities from 2011 to future year 2025; we use 2025 projected emissions for year 2023. Additional new kiln emissions generated by ISMP are discussed in Section 4.2.5.4. There are some local exceptions where the EPA did not use ISMP-based projections for cement kilns where local information from consent decrees/settlements and state comments were used instead. Cement kilns projected using these non-ISMP information are not reflected here in Table 4-25.

Table 4-25. ISMP-based cement industry projected emissions for 2023en

	Emissions		Tons Difference	% Difference
	2011	2025	2025	2025
NO_X	47,270	67,856	20,586	43.6%
PM_{10}	2,743	967	-1,776	-64.8%

$PM_{2.5}$	1,523	598	-925	-60.7%
SO_2	11,520	21,534	10,014	86.9%
VOC	2,329	940	-1,390	-59.7%

4.2.3.8 Corn ethanol plants (ptnonipm)

Packet:
"PROJECTION_2011_2025_Corn_Ethanol_Plants_AEO2014_Table17_2011v6.2_19feb2015_v0.txt"

We used the AEO 2014 renewable forecast projections of "From Corn and Other Starch" to compute national year 2025 growth in ethanol plant production. Per OTAQ direction, we exempted two facilities ('Highwater Ethanol LLC' in Redwood county MN and 'Life Line Foods LLC-St. Joseph' in Buchanan county MO) from these projections; future year emissions were equal to their 2011 NEI v2 values for these two facilities.

The 2011 corn ethanol plant emissions were projected to account for the change in domestic corn ethanol production between 2011 and future years, from approximately 13.9 Bgal (billion gallons) in 2011 to 13.2 Bgal by 2025 based on AEO 2014 projections. The projection was applied to all pollutants and all facilities equally. Table 4-26 provides the summaries of estimated emissions for the corn ethanol plants in 2011 and future year 2025.

Table 4-26. 2011 and 2025 corn ethanol plant emissions [tons]

	Emissions		Difference	% Change
	2011	**2025**	**2025**	**2025**
CO	877	831	-46	-5.19%
NO_x	1,328	1,259	-69	-5.19%
PM_{10}	1,259	1,194	-65	-5.19%
$PM_{2.5}$	302.243	286.545	-16	-5.19%
SO_2	9.52755	9.03272	0	-5.19%
VOC	3,084	2,924	-160	-5.19%

4.2.3.9 Residential wood combustion (rwc)

Packet:
"PROJECTION_2011_2023_RWC_2011v6.3.csv"
"BETA_Projections_RWC_2023_18apr2016_emf.csv" (MARAMA)

The EPA applied the recently-promulgated national NSPS for wood stoves to the RWC projections methodology for this platform. To learn more about the strengthened NSPS for residential wood heaters, see http://www2.epa.gov/residential-wood-heaters/regulatory-actions-residential-wood-heaters. The EPA projected RWC emissions to year 2017 and 2025 based on expected increases and decreases in various residential wood burning appliances. The EPA linearly interpolated these factors to year 2023 for this modeling platform. As newer, cleaner woodstoves replace ***some*** older, higher-polluting wood stoves, there will be an overall reduction of the emissions from older "dirty" stoves but an overall increase in total RWC due to population and sales trends in all other types of wood burning devices such as indoor furnaces and outdoor hydronic heaters (OHH). It is important to note that our RWC projection methodology does not explicitly account for state or local residential wood control programs. There are a number more-stringent state and local rules in place in 2011, specifically in California, Oregon and Washington. However, at this time, the EPA does not have enough detailed information to calculate state specific or local area growth rates. Therefore, with the exception of California, Oregon and Washington, the EPA is using national level growth rates for each RWC SCC category. After discussions with California air districts, regional office contacts and EPA experts, the EPA decided to hold RWC emissions flat (unchanged) for all SCCs in California, Oregon and Washington.

Assumed Appliance Growth and Replacement Rates

The development of projected growth in RWC emissions to year 2017 and 2025 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 (EPA, 2013b), also 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 (EPA, 2013b), 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 percent per year from 2013 through 2025 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 percent (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 percent of new woodstoves will replace older non-EPA certified freestanding stoves (pre-1988 NSPS) and 5 percent will replace existing EPA-certified catalytic and non-catalytic stoves that currently meet the 1988 NSPS (Houck, 2011).

The EPA RWC NSPS experts assume that 10 percent of new pellet stoves and OHH replace older units and that because of their short lifespan, that 10 percent 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 2011 varies greatly between appliance types.

NSPS Overview

The residential wood heaters NSPS final rule was promulgated on February 3, 2015. This rule does not affect existing woodstoves or other wood burning devices; however, it does provide more stringent emissions standards for new woodstoves, outdoor hydronic heaters and indoor wood-burning forced air furnaces. New "Phase 1" less-polluting heater standards began in 2015, with even more-stringent Phase 2 standards beginning in 2020. The associated reduced emission rates for each appliance type (SCC) are applied to all new units sold, some of which are assumed to replace retired units, since year 2015.

Currently the 1988 NSPS limits primary $PM_{2.5}$ emissions from adjustable burn rate stoves, including fireplace inserts and freestanding woodstoves, to 7.5 grams/hour (g/hr) for non-catalytic stoves and 4.1 g/hr for catalytic stoves. The final NSPS limits $PM_{2.5}$ emissions for room heaters, which include adjustable and single burn rate stoves and pellet stoves to 4.5 g/hr in 2015 and 1.3 g/hr in 2020. In addition, the final NSPS limits $PM_{2.5}$ emissions from hydronic heaters to 0.32 lb/MMBtu heat output in 2015, and 0.06 lb/MMBtu in 2020. The final NSPS limits $PM_{2.5}$ emissions from indoor furnaces to 0.93 lb/MMBtu in 2015 and 0.06/MMBtu in 2020.

Emission factors were estimated from the 2011v2 NEI based on tons of emissions per appliance for $PM_{2.5}$, VOC and CO. This calculation was based on estimated appliance (SCC) population and total emissions by SCC. EPA-certified wood stove emission factors are provided in the wood heaters NSPS RIA Tables 4-3, 4-7 and 4-11 for $PM_{2.5}$, VOC and CO, respectively. For all RWC appliances subject to the NSPS, baseline RIA emission factors, when lower than the computed emission factors (2011 NEI), are used for new appliances sold between 2012 and 2014. Starting in 2015, Phase 1 emission limits are 60 percent stronger (0.45 g/hr / 0.75 g/hr) than the RIA baseline emission factors. There are also different standards for catalytic versus non-catalytic EPA-certified stoves. Similar calculations are performed for Phase 2 emission limits that begin in 2020 and for different emission rates for different appliance types. Because the 2011NEI and RIA baseline (2012-2014) emission factors vary by pollutant, all RWC appliances subject to the NSPS have pollutant-specific "projection" factors. We realize that these "projection" factors are a composite of growth, retirements and potentially emission factors in 4 increments. More detailed documentation on the EPA RWC Projection Tool, including information on baseline, new appliances pre-NSPS, and Phase 1 and Phase 2 emission factors, is available upon request.

Caveats and Results

California, Oregon and Washington have state-level RWC control programs, including local burn bans in place. Without an ability to incorporate significant local RWC control programs/burn bans for a future year inventory, the EPA left RWC emissions unchanged in the future for all three states. The RWC projections factors for states other than California, Oregon and Washington are provided in Table 4-27. VOC HAPs use the same projection factors as VOC; PM_{10} uses the same factor as $PM_{2.5}$; and all other pollutants use the CO projection factor. Note that appliance types not subject to the wood heaters NSPS (e.g., fire pits, fire logs) have pollutant-independent projection factors because there is no assumed change in future year emission factors.

Table 4-27. Non-West Coast RWC projection factors, including NSPS impacts

SCC	Description	Default if pollutant not defined	PM	VOC and VOC HAPs	CO and remaining CAPs
2104008100	Fireplace: general	1.127			
2104008210	Woodstove: fireplace inserts; non-EPA certified	0.791			
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic	1.238	1.103		
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic	1.281	1.128		
2104008310	Woodstove: freestanding, non-EPA certified	0.829	0.828	0.842	0.829
2104008320	Woodstove: freestanding, EPA certified, non-catalytic	1.238	1.103		
2104008330	Woodstove: freestanding, EPA certified, catalytic	1.281	1.129		
2104008400	Woodstove: pellet-fired, general	1.852	1.898		

SCC	Description	Default if pollutant not defined	PM	VOC and VOC HAPs	CO and remaining CAPs
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified	0.277	0.318	0.276	0.277
2104008610	Hydronic heater: outdoor	1.044	1.079		
2104008700	Outdoor wood burning device, NEC	1.127			
2104009000	Residential Firelog Total: All Combustor Types	1.127			

National emission summaries for the RWC sector in 2011 and 2023 are provided in Table 4-**28**. For direct PM, the NSPS emission factor reductions mostly offset the growth in appliances by year 2023.

Table 4-28**.** Cumulative national RWC emissions from growth, retirements, and NSPS impacts

Pollutant	Emissions		Difference	% Difference
	2011	2023	2023 - 2011	2023- 2011
CO	2,526,548	2,376,924	149,624	5.92%
NH_3	19,759	18,560	1,199	6.07%
NO_X	34,518	35,000	-483	-1.40%
PM_{10}	382,754	364,067	18,687	4.88%
$PM_{2.5}$	382,528	363,818	18,710	4.89%
SO_2	8,975	7,926	1,049	11.68%
VOC	444,269	417,315	26,954	6.07%

4.2.4 CoST CONTROL Packets (nonpt, np_oilgas, ptnonipm, pt_oilgas)

The final step in a CoST control strategy, after application of any/all CLOSURE packet(s) (point inventories only) and any/all PROJECTION packet(s) is the application of CoST CONTROL packets. While some controls are embedded in our PROJECTION packets (e.g., NSPS controls for RWC and loco-marine controls for rail and commercial marine vessels), we attempted to separate out the control (program) component in our modeling platform where feasible. In our platform, CoST control packets only impact the nonpt, np_oilgas, ptnonipm and pt_oilgas sectors.

There are several different sources of CONTROL data that are concatenated and quality-assured for duplicates and applicability to the inventories in the CoST strategies. We broke up the CONTROL (and PROJECTION) packets into a few "key" control program types to allow for quick summaries of these distinct control programs. The remainder of this section is broken out by CoST packet, with the exception of discussion of the various packets gathered from previous versions of the emissions modeling platform; these packets are a mix of different sources of data, only some of which have not been replaced by more recent information gathered for this platform.

For future-year NSPS controls (oil and gas, 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.

$$Qn = Qo \{ [(1 + Pf) t – 1] Fn + (1 - Ri) t \ Fe + [1 - (1 - Ri) t] Fn] \} \qquad \textbf{\textit{Equation 1}}$$

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 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 2 was used for 2023 projections:

$$Control\_Efficiency_{2023}(\%) = 100 * (1- [(Pf_{2023}-1)*Fn + (1-Ri)^{12} + (1-(1-Ri)^{12})*Fn]/ Pf_{2023}) \qquad \text{Equation 2}$$

Here, the existing source emissions factor (Fe) is set to 1.0, 2023 (future year) minus 2011 (base year) is 12, and new source emission factor (Fn) is the ratio of the NSPS emission factor to the existing emission factor. Table 4-29 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; this table also provides the subsection where the CONTROL packets are discussed.

Table 4-29. Assumed retirement rates and new source emission factor ratios for various NSPS rules

NSPS Rule	TSD Section	Retirement Rate years (%/year)	Pollutants Impacted	Applied where?	New Source Emission Factor (Fn)
Oil and Gas	4.2.4.1	No assumption	VOC	Storage Tanks: 70.3% reduction in growth-only (>1.0)	0.297
				Gas Well Completions: 95% control (regardless)	0.05
				Pneumatic controllers, not high-bleed >6scfm or low-bleed: 77% reduction in growth-only (>1.0)	0.23
				Pneumatic controllers, high-bleed >6scfm or low-bleed: 100% reduction in growth-only (>1.0)	0.00
				Compressor Seals: 79.9% reduction in growth-only (>1.0)	0.201
				Fugitive Emissions: 60% Valves, flanges, connections, pumps, open-ended lines, and other	0.40
				Pneumatic Pumps: 71.3% Oil and Gas	0.287
RICE	4.2.4.3	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	4.2.4.6	45 (2.2%)	NO_X	California and NO_X SIP Call states	0.595
				All other states	0.238
Process Heaters	4.2.4.7	30 (3.3%)	NO_X	Nationally to Process Heater SCCs	0.41

4.2.4.1 Oil and Gas NSPS (np_oilgas, pt_oilgas)

Packet:
"oilgas_2011_2023en_control_packet_NSPS_27jul2017_07aug2017_v0"
"CONTROL_2023_OILGAS_VOC_NSPS_csv_07aug2017_v2"
"BETA_Controls_OilGas_NSPS_2023_29apr2016.csv" (MARAMA)

For oil and gas NSPS controls, with the exception of gas well completions (a 95 percent control), the assumption of no equipment retirements through year 2023 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 4-29, 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. Because these impacts are so geographically varying, we are providing the VOC NSPS reductions by each of the 6 broad NEMS regions, with Texas and New Mexico aggregated because these states include multiple NEMS regions (see Figure 4-1). These reductions are year-specific because projection factors for these sources are year-specific.

Table 4-30. NSPS VOC oil and gas reductions from projected pre-control 2023en grown values

Region	Pre-NSPS emissions	Post-NSPS emissions	NSPS Reductions	NSPS % reductions
Gulf Coast	1,066	53	1,013	95%
Midcontinent	72,774	58,883	13,891	19%
New Mexico/Texas*	1,250,016	914,867	335,149	27%
Northeast	291,465	123,494	167,970	58%
Rocky Mountains	753,719	388,716	365,002	48%
West Coast	358	30	328	92%
Overall	2,369,397	1,486,043	883,354	37%

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

Packet:

"CONTROL_2011v6.2_RICE_NESHAP_v2_30jan2015_v0.txt"
"BETA_Controls_RICE_NESHAP_29apr2016" (MARAMA)

There are two rulemakings for National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE). These rules reduce HAPs from existing and new RICE sources. In order to meet the standards, existing sources with certain types of engines will need to install controls. In addition to reducing HAPs, these controls have co-benefits that also reduce CAPs, specifically, CO, NOx, VOC, PM, and SO_2. In 2014 and beyond, compliance dates have passed for both rules and are thus included in emissions projections. These RICE reductions also reflect the Reconsideration Amendments (proposed in January, 2012), which result in significantly less stringent NOx controls (fewer reductions) than the 2010 final rules.

The rules can be found at https://www.epa.gov/stationary-engines and are listed below:

- National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines; Final Rule (FR 9648) published 03/03/10.
- National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines; Final Rule (75 FR 51570) published 08/20/2010.

The difference among these two rules is that they focus on different types of engines, different facility types (major for HAPs, versus area for HAPs) and different engine sizes based on horsepower. In addition, they have different compliance dates, though both are after 2011 and fully implemented prior to 2017. The EPA projects CAPs from the 2011NEIv2 RICE sources, based on the requirements of the rule for existing sources only because the inventory includes only existing sources. The EPA estimates the NSPS (new source) impacts from RICE regulations in a separate CONTROL packet and CoST strategy; the RICE NSPS is discussed in the next section.

The "Regulatory Impact Analysis (RIA) for the Reconsideration of the Existing Stationary Compression Ignition (CI) Engines NESHAP: Final Report" (EPA, 2013ci) is available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/RICE_NESHAPreconsideration_Compression_Ignition_Engines_RIA_final2013_EPA.pdf. The "Regulatory Impact Analysis (RIA) for Reconsideration of the Existing Stationary Spark Ignition (SI) RICE NESHAP: Final Report" (EPA, 2013si) is available at: http://www.epa.gov/ttn/ecas/regdata/RIAs/NESHAP_RICE_Spark_Ignition_RIA_finalreconsideration2013_EPA.pdf. Together, the EPA calls these the RICE NESHAP amendment RIA's for SI and CI engines. From these RICE NESHAP RIA documents, the EPA obtained cumulative RICE reductions for all SCCs represented by CI and SI engines. These aggregate reductions and percent reductions from baseline emissions (not the 2011NEIv2) are provided in Table 4-31. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-31. Summary RICE NESHAP SI and CI percent reductions prior to 2011NEIv2 analysis

	CO	NO_X	PM	SO_2	VOC
RIA Baseline: SI engines	637,756	932,377			127,170
RIA Reductions: SI engines	22,211	9,648			9,147
RIA Baseline: CI engines	81,145		19,369	11,053	79,965

	CO	NO_X	PM	SO_2	VOC
RIA Reductions: CI engines	14,238		2,818	5,100	27,142
RIA Cumulative Reductions	36,449	9,638	2,818	5,100	36,289
SI % reduction	3.5%	1.0%	n/a	n/a	7.2%
CI % reduction	17.5%	n/a	14.5%	46.1%	33.9%

These RIA percent reductions were used as an ***upper-bound*** for reducing emissions from RICE SCCs in the 2011NEIv2 point and nonpoint modeling sectors (ptnonipm, nonpt, pt_oilgas and np_oilgas). To begin with, the RIA inventories are based on the 2005 NEI, so the EPA wanted to ensure that our 2011 reductions did not exceed those in the RICE RIA documents. For the 2011 platform, the EPA worked with EPA RICE NESHAP experts and developed a fairly simple approach to estimate RICE NESHAP reductions. Most SCCs in the inventory are not broken down by horsepower size range, mode of operation (e.g., emergency mode), nor major versus area source type. Therefore, the EPA summed NEI emissions nationally by SCC for RICE sources and also for sources that were at least partially IC engines (e.g., "Boiler and IC engines"). Then, the EPA applied the RIA percent reductions to the 2011NEIv2 for SCCs where national totals exceeded 100 tons; the EPA chose 100 tons as a threshold, assuming there would be little to no application of RICE NESHAP controls on smaller existing sources.

Next, the EPA aggregated these national reductions by engine type (CI vs. SI) and pollutant and compared these to the RIA reductions. As expected, for most pollutants and engine types, the cumulative reductions were significantly less than those in the RIA. The only exception was for SO_2 CI engines, where the EPA scaled the RIA percent reduction from 46.1 percent to 14.4 percent for four broad nonpoint SCCs that were not restricted to only RICE engines. These four SCCs were the "Boilers and IC Engines" or "All processes" that would presumably contain some fraction of non-RICE component. This had minimal impact as sulfur content in distillate fuel for many IC engine types has decreased significantly since 2005. Reducing the SO_2 percent reduction for these four SCCs resulted in slightly less than 5,100 tons of SO_2 reductions overall from only RICE NESHAP controls. However, more specific CoST projection packets would later override these RICE NESHAP reductions for SO_2. Recall the CoST hierarchy discussed earlier; these RICE NESHAP reductions are national by pollutant and SCC and thus easily overridden by more-specific information such as state-level fuel sulfur rules (discussed in the next section).

Additional comments from the NODA were also implemented; specifically, CO controls were modified for a couple of distillate-fueled industrial/commercial boiler sources. Impacts of the RICE NESHAP controls on nonpt, ptnonipm, pt_oilgas and np_oilgas sector emissions are provided in Table 4-32. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-32. National by-sector reductions from RICE Reconsideration controls for 2023en (tons)

Pollutant	Year	Nonpoint Oil & Gas (np_oilgas)	Point Oil & Gas (pt_oilgas)	Nonpoint (nonpt)	Point (ptnonipm)	Total
CO	2023	11,051	5,452	3,505	6,357	26,365
NOX	2023	3,008	2,238	216	83	5,545
PM10	2023	0	8	1,038	306	1,352
PM2.5	2023	0	8	913	289	1,210
SO2	2023	0	11	2,951	307	3,269
VOC	2023	2,192	3,723	622	934	7,471

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

Packet:

“oilgas_2011_2023en_control_packet_RICE_NSPS_27jul2017_07aug2017_v0”
“CONTROL_2011v6_3_2023_RICE_NSPS_18oct2016_07aug2017_v1:

“BETA_Controls_RICE_NSPS_2023_30jul2016_csv_07aug2017_v1” (MARAMA)

Controls for existing RICE source emissions were discussed in the previous section. This section discusses control for new equipment sources, NSPS controls that impact CO, NOx and VOC. 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 versus four stroke, and whether the engine is rich burn or lean burn.

RICE engines in the NOx SIP Call area are covered by state regulations implementing those requirements. EPA estimated that NOx emissions within the control region were expected to be reduced by about 53,000 tons per 5month ozone season in 2007 from what they would otherwise be without this program. Federal rules affecting RICE included the NESHAP for RICE (40 CFR part 63, Subpart ZZZZ), NSPS for Stationary Spark Ignition IC engines (40 CFR part 60, Subpart JJJJ), and NSPS for Compression Ignition IC engines (40 CFR part 60, Subpart IIII). SI engine operators were affected by the NSPS if the engine was constructed after June 12, 2006, with some of the smaller engines affected by the NSPS 1-3 years later. The recommended RICE equipment lifetime is 30 to 40 years depending on web searches. We chose 40 years as a conservative estimate.

The 2011 estimates of the RICE engine average emission rates for lean burn and rich burn engines was developed using the stationary engine manufacturers data submitted to the EPA for the NSPS analysis (Parise, 2005). Emission factors by pollutant for engines 500-1200 horsepower (hp) were used to develop the average emission rates. The analysis was organized this way because lean versus rich burn engine type is such a significant factor in the NOx emissions rate. Any state emission regulations that require stationary RICE engines to achieve emission levels lower than the 2012 NSPS could be included by using lower new source emission ratios that account for the additional emission reductions associated with having more stringent state permit rules. Information is provided for Pennsylvania in Table 4-33. That information shows that the Pennsylvania regulations have different emission standards for lean burn versus rich burn engines, and that the emission limits also vary by engine size (100-500 hp or greater than 500 hp). While some of the newer RICE SCCs (oil and gas sector in particular) allow states to indicate whether engines are lean versus rich burn, some SCCs lump these two together. None of the RICE point source SCCs have information about engine sizes. However, the EPA RIA for the RICE NSPS and NESHAP analysis (RTI, 2007) provides a table that shows the NOx (CO, NMHC and HAP emission estimates are provided as well) emissions in 2015 by engine size, along with engine populations by size. In the future, more rigorous analysis can use this table to develop computations of weighted average emission reductions by rated hp to state regulations like Pennsylvania’s.

Table 4-33. RICE NSPS Analysis and resulting 2011v6.2 emission rates used to compute controls

Engine type & fuel	Max Engine Power	Geographic Applicability	Emission standards g/HP-hr		
			NO_X	**CO**	**VOC**
2011 pop lean burn	500-1200 hp		1.65	2.25	0.7
2011 pop rich burn	500-1200 hp		14.5	8	0.45
Non-Emerg. SI NG and Non-E. SI Lean Burn LPG (except LB 500≤HP<1,350)	HP≥100	2006 NSPS	2.0	4.0	1.0
Non-Emerg. SI NG and Non-E. SI Lean Burn LPG (except LB 500≤HP<1,350)	HP≥100	2012 NSPS	1.0	2.0	0.7
	HP≥100	PA (Previous GP-5)	2.0	2.0	2.0
New NG Lean Burn	100<HP<500	PA (New GP-5)	1.0	2.0	0.7
New NG Lean Burn	HP >500	PA (New GP-5)	0.5	2.0	0.25
New NG Rich Burn	100<HP<500	PA (New GP-5)	0.25	0.3	0.2
New NG Rich Burn	HP >500	PA (New GP-5)	0.2	0.3	0.2
	HP≥100	Maryland	1.5		
	HP>7500	Colorado	1.2 - 2		
		Wyoming	None	None	None
Notes: the above table compares the criteria pollutant emission standards from the recent NSPS with the emission limits from selected states for stationary IC engines to determine whether future year emission rates are likely to be significantly lower than for the existing engine population. States in the NO_X SIP Call region instituted NO_X emission limits for large engines well before 2011. Most of the values in the above table come from an analysis posted on the PA DEP website. The state emission limits listed above are those in place prior to 2011. Some states (like PA) have instituted tougher RICE emission limits for new and modified engines more recently.					
Note 2: Wyoming exempts all but the largest RICE engines from emission limits.					
Note 3: PA has had a size limit for new RICE engines of 1500 hp until recently (i.e., not engines bigger than 1500 hp can be installed). Their new General Permit-5 removed the engines size cap, but requires new or modified larger engines to be cleaner (i.e., has emission limits lower than the NSPS). PA expects that the new emission limits will result in an increase in larger engines being installed, and bringing the average emission rate much lower than it is currently.					
New source Emissions Rate (Fn): Controls % =100 * (1-Fn)			**NO_X**	**CO**	**VOC**
Pennsylvania	NG-Comb. LB & RB		0.175	0.575	0.113
All other states	NG-Comb. LB & RB		0.338	0.569	1.278
Pennsylvania	NG-lean burn		0.250	1.000	0.125
All other states	NG-lean burn		0.606	0.889	1.000
Pennsylvania	NG-rich burn		0.100	0.150	0.100
All other states	NG-rich burn		0.069	0.250	1.556

We applied NSPS reduction for lean burn, rich burn and “combined” (not specified). We also computed scaled-down (less-stringent) NSPS controls for SCCs that were “IC engines + Boilers” because boiler emissions are not subject to RICE NSPS. For these SCCs, we used the 2011NEIv2 point inventory to aggregate eligible (fuel and type) boiler and IC engine emissions for each pollutant. We found that for CI engines, almost all emissions were boiler-related; therefore, there are no CI engine RICE NSPS reductions for “IC engines + Boilers.” For SI engines, we found that approximately 9 percent of NOx, 10 percent of CO and 19 percent of VOC “IC engines + Boilers” were IC engines; these splits were then applied to the NSPS reductions in Table 4-33. Finally, we limited RICE NSPS-eligible sources (SCCs) to those that have at least 100 tons nationally for NOx, CO or VOC, and ignored resulting controls that were under 1 percent.

Pennsylvania DEP staff note that until recently they have limited RICE engines to a maximum of 1500 hp. That cap is lifted under the new General Permit-5 regulations. With that cap lifting, Pennsylvania expects that new applications will choose to install larger engines which have lower emission limits. However, that potential effect will be difficult to capture with no information about how this might occur. These controls were then plugged into *Equation 2* (see Section 4.2.4) as a function of the projection factor. Resulting controls greater than or equal to 1 percent were retained. Note that where new emissions factors >=1.0 (uncontrolled, as represented by red cells at the bottom of Table 4-33), no RICE NSPS controls were computed. National RICE NSPS reductions from projected pre-NSPS 2023 inventory is shown in Table 4-34. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-34. National by-sector reductions from RICE NSPS controls for 2023en (tons)

Pollutant	Year	Nonpoint Oil & Gas (np_oilgas)	Point Oil & Gas (pt_oilgas)	Nonpoint (nonpt)	Point (ptnonipm)	Total NSPS reductions	Pre-NSPS total emissions	NSPS % reduction
CO	2023	37,637	45,012	2,278	1,344	86,270	396,892	22%
NOX	2023	42,141	108,925	3,903	2,027	156,997	574,683	27%
VOC	2023	2,641	689	0	2	3,332	5,528	60%

4.2.4.4 ICI boilers (nonpt, ptnonipm, pt_oilgas)

Packets:

CONTROL_2011v6.2_20xx_BoilerMACT_POINT_v2_30jan2015_v0.txt
CONTROL_2011v6.2_20xx_BoilerMACT_NONPT_08jan2015_11jan2016_nf_v1.txt
NCDAQ_CONTROL_2011v6_2_2017_BoilerMACT_POINT_revised_07jan2016_v0.txt
BETA_Controls_BOILER_MACT_24aug2016.csv (MARAMA)

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/clean-air-act-standards-and-guidelines-energy-engines-and. 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 SO_2 with lesser impacts for direct PM, CO and VOC. These packets address only the expected cobenefits to existing ICI boilers. MARAMA supplied their own control packet that covers the MACT Rule impacts for their states.

Boiler MACT reductions were computed from a non-NEI database of ICI boilers. As seen in the Boiler MACT Reconsideration RIA (see docket item EPA-HQ-OAR-2002-0058-3876 on http://regulations.gov, EPA 2011c), this Boiler MACT Information Collection Request (ICR) dataset computed over 558,000 tons of SO_2 reductions by year 2015. However, the Boiler MACT ICR database and reductions are based on the assumption that if a unit *could* burn oil, it *did* burn oil, and often to capacity. With high oil prices and many of these units also able to burn cheaper natural gas, the 2011NEIv2 inventory has a lot more gas combustion and a lot less oil combustion than the boiler MACT database. For this reason, the EPA decided to target units that potentially could be subject to the Boiler MACT and compute preliminary reductions for several CAPs prior to building a control packet.

Step 1: Extract facilities/sources potentially subject to Boiler MACT

This step is only applicable to point inventory sources. The EPA did not attempt to map each ICR unit to the NEI units, instead choosing to use a more general approach to extract NEI sources that would be potentially subject to, and hence have emissions reduced by the Boiler MACT. The NEI includes a field that indicates whether a facility is a major source of HAPs and/or CAPs. This field in our FF10 point inventory modeling file is called "FACIL_CATEGORY_CODE" and the possible values for that field are shown in Table 4-35.

Table 4-35. Facility types potentially subject to Boiler MACT reductions

Code	Facility Category	Subject to Boiler MACT?	Description
CAP	CAP Major	N	Facility is Major based upon 40 CFR 70 Major Source definition paragraph 2 (100 tpy any CAP. Also meets paragraph 3 definition, but NOT paragraph 1 definition).
HAP	HAP Major	Y	Facility is Major based upon only 40 CFR 70 Major Source definition paragraph 1 (10/25 tpy HAPs).
HAPCAP	HAP and CAP Major	Y	Facility meets both paragraph 1 and 2 of 40 CFR 70 Major Source definitions (10/25 tpy HAPs and 100 tpy any CAP).
HAPOZN	HAP and O3 n/a Major	Y	Facility meets both paragraph 1 and 3 of 40 CFR 70 Major Source definitions (10/25 tpy HAPs and Ozone n/a area lesser tons for NO_X or VOC).
NON	Non-Major	N	Facility's Potential to Emit is below all 40 CFR 70 Major Source threshold definitions without a FESOP.
OZN	O3 n/a Major	N	Facility is Major based upon only 40 CFR 70 Major Source definition paragraph 3 (Ozone n/a area lesser tons for NO_X or VOC).
SYN	Synthetic non-Major	N	Facility has a FESOP which limits its Potential To Emit below all three 40 CFR 70 Major Source definitions.
UNK	Unknown	N	Facility category per 40 CFR 70 Major Source definitions is unknown.

Because the Boiler MACT rule applies to only major sources of HAPs, the EPA restricted the universe of facilities potentially subject to the Boiler MACT to those classified as HAP major or unknown (UNK). The third column indicates whether the facility was a candidate for extraction as being potentially subject to the Boiler MACT.

Step 2: Merge control information with 2011 NEI and apply state NODA comments

The EPA analyzed the SCCs in the OTC 2007 inventories and tweaked the SCC mapping of these ICI boiler adjustments to map to those in the 2011 NEI point and nonpoint inventory with non-zero emissions. The EPA also removed some duplicate and incorrect mappings and expanded the SCC mapping in some cases to SCCs that were in the NEI, but not the OTC inventory (and thus missing from the analysis).

Some states commented on the 2011v6.0 ICI boiler controls via the 2018 NODA (docket # EPA-HQ-OAR-2013-0809 on http://www.regulations.gov). Wisconsin provided alternative SO_2, VOC and HCl controls for stoker and pulverized coal fueled units. The national-level and Wisconsin-specific ICI boiler adjustments, applied at the unit-level for point sources and by SCC (and state for Wisconsin) are provided in Table 4-36; note that we applied the same national-level adjustments to CO, NOx and PM for coal units in Wisconsin. New York and New Jersey, via the MARAMA comment/data to the 2018 NODA, provided boiler rule NOx reductions that also supersede these nationally-applied factors. The New Jersey and New York factors are provided in Table 4-37; note that New Jersey controls apply only to nonpoint sources and that New York controls vary by fuel for point sources.

Table 4-36. National-level, with Wisconsin exceptions, ICI boiler adjustment factors by base fuel type

Unit/Fuel Type	Default % Reduction (Adjustments)					
	CO	NOX	PM	SO2	VOC	HCl
Stoker Coal	98.9	70.7	96	97.4	98.9	95
Pulverized Coal	98.9	60.6	72.2	73	98.9	95
Residual Oil	99.9	57	92.4	97.1	99.9	95
Distillate Oil	99.9	38.8	68.4	99.9	99.9	88.6
Wisconsin: Stoker Coal	98.9	70.7	96	30	0	45
Wisconsin: Pulverized Coal	98.9	60.6	72.2	30	0	45

Table 4-37. New York and New Jersey NO_X ICI Boiler Rules that supersede national approach

NJ and NY Boiler Rule controls	NOX % Reduction
New Jersey Small Boiler Rule (nonpoint only): Default for Distillate, Residual, natural gas and LPG	25
New York Small Boiler Rule (nonpoint only): Default for Distillate, Residual, natural gas and LPG	10
NY Boiler Rule: Industrial /Distillate Oil /< 10 Million Btu/hr	10
NY Boiler Rule: Industrial /Residual Oil /10-100 Million Btu/hr	33.3
NY Boiler Rule: Electric Gen /Residual Oil /Grade 6 Oil: Normal Firing	40
NY Boiler Rule: Electric Gen /Natural Gas /Boilers, < 100 Million Btu/hr except Tangent	50
NY Boiler Rule: Electric Gen /Natural Gas /Boilers, 100 Million Btu/hr except Tangent	60
NY Boiler Rule: Industrial /Bitum Coal /Cyclone Furnace	66.7
NY Boiler Rule: Industrial /Natural Gas /> 100 Million Btu/hr	70
NY Boiler Rule: Electric Gen /Bituminous Coal /Pulverized Coal: Dry Bottom	73.3

The impacts of these ICI boiler reductions are provided in Table 4-38. This table reflects the impacts of both the MARAMA and non-MARAMA packets. Overall, the CO and $PM_{2.5}$ reductions are reasonably close to the year-2015 expected reductions in the Boiler MACT Reconsideration RIA (see docket item EPA-HQ-OAR-2002-0058-3876 on http://regulations.gov). It is worth noting that the SO_2 reductions in the preamble for the Boiler MACT Reconsideration (76 FR 80532; https://www.epa.gov/stationary-sources-air-pollution/industrial-commercial-and-institutional-boilers-and-process-heaters) were estimated at 442,000 tons; the additional SO_2 reductions in the reconsideration are from an additional co-benefit from more stringent HCl controls. The 2011NEIv2 SO_2 emissions are actually less than the estimated Boiler MACT reductions, likely a result of numerous units undergoing fuel switching from coal or oil to natural gas.

Table 4-38. Summary of ICI Boiler reductions for 2023en

Year	Pollutant	Emissions Eligible for Control	Controlled (Final) Emissions	Reductions (tons)	% Reductions
CO	2023	20,568	3,760	16,808	81.7%
NOX	2023	65,430	31,226	34,204	52.3%
PM10	2023	9,050	2,140	6,910	76.4%
PM2.5	2023	6,540	1,601	4,939	75.5%

SO2	2023	142,660	25,677	116,983	82.0%
VOC	2023	1,222	187	1,035	84.7%

4.2.4.5 Fuel sulfur rules (nonpt, ptnonipm, pt_oilgas)

Packet:

"CONTROL_2011v6.2_20xx_Fuel_Sulfur_Rules_09jan2015_v0.txt"
"BETA_Controls_MANEVU_SULFUR_2016_08_24.csv" (MARAMA)

Fuel sulfur rules, based on web searching and the 2011 emissions modeling NODA comments, are currently limited to the following states: Connecticut, Delaware, Maine, Massachusetts, 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 all of these states.

A summary of all fuel sulfur rules provided back to the EPA by the 2011 emissions modeling NODA comments is provided in Table 4-39. State-specific control factors were computed for distillate, residual and #4 fuel oil using each state's baseline sulfur contents and the sulfur content in the rules. For most states, the baseline sulfur content was 3,000 ppm (0.3 percent) for distillate oil, and 2.25 percent for residual and #4 oil. However, many states had lower baseline sulfur contents for residual oil, which varied by state and county. The SRA used state- or county-specific baseline residual oil sulfur contents to calculate a state- or county-specific control factors for residual oil (SRA, 2014).

A summary of the sulfur rules by state, with emissions reductions is provided in Table 4-40. This table reflects the impacts of the MARAMA packet only, as these reductions are not estimated in non-MARAMA states. Most of these reductions (98+ percent) occur in the nonpt sector; a small amount of reductions occur in the ptnonipm sector, and a negligible amount of reductions occur in the pt_oilgas sector. Note that these reductions are based on intermediate 2023 inventories, those grown from 2011 to the specific future years.

Table 4-39. State Fuel Oil Sulfur Rules data provided by MANE-VU

State	Reference
Connecticut	Section 22a-174-19a. Control of sulfur dioxide emissions from power plants and other large stationary sources of air pollution: Distillate and Residual: 3000 ppm effective April 15, 2014. Section 22a – 174 - 19b. Fuel Sulfur Content Limitations for Stationary Sources (except for sources subject to Section 22a-174-19a). Distillate: 500 ppm effective July 1, 2014; 15 ppm effective July 1, 2018 Residual: 1.0% effective July 1, 2014; 0.3% effective July 1, 2018 Connecticut General Statute 16a-21a. Sulfur content of home heating oil and off-road diesel fuel. Number 2 heating oil and off-road diesel fuel: 500 ppm effective July 1, 2014; 15 ppm effective July 1, 2018 See: http://www.ct.gov/deep/cwp/view.asp?a=2684&Q=322184&deepNav_GID=1619
Delaware	1108 Sulfur Dioxide Emissions from Fuel Burning Equipment Distillate: 15 ppm effective July 1, 2017 Residual: 0.5% effective July 1, 2017 #4 Oil: 0.25% effective July 1, 2017 See: http://regulations.delaware.gov/AdminCode/title7/1000/1100/1108.shtml
Maine	Chapter l06: Low Sulfur Fuel Distillate: 500 ppm effective July 1, 2014; 15 ppm effective July 1, 2018 Residual: 0.5% effective July 1, 2018 See: http://www.mainelegislature.org/legis/bills/bills_124th/billpdfs/SP062701.pdf.
Massachusetts	310 CMR 7.05 (1)(a)1: Table 1 : Sulfur Content Limit of Liquid Fossil Fuel Distillate: 500 ppm effective July 1, 2014; 15 ppm effective July 1, 2018 Residual: 1.0% effective July 1, 2014; 0.5% effective July 1, 2018 See: http://www.mass.gov/eea/docs/dep/service/regulations/310cmr07.pdf
New Jersey	Title 7, Chapter 27, Subchapter 9 Sulfur in Fuels

State	Reference
	Distillate: 500 ppm effective July 1, 2014; 15 ppm effective July 1, 2016 Residual: 0.5% or 0.3%, depending on county, effective July 1, 2014 #4 Oil: 0.25% effective July 1, 2014 See: http://www.nj.gov/dep/aqm/rules27.html
New York	Subpart 225-1 Fuel Composition and Use - Sulfur Limitations Distillate: 15 ppm effective July 1, 2016 Residual: 0.3% in New York City effective July 1, 2014; 0.37% in Nassau, Rockland and Westchester counties effective July 1, 2014; 0.5% remainder of state effective July 1, 2016 See: http://www.nyc.gov/html/dep/html/news/dep_stories_p3-109.shtml and http://green.blogs.nytimes.com/2010/07/20/new-york-mandates-cleaner-heating-oil/?_r=1 and http://switchboard.nrdc.org/blogs/rkassel/governor_paterson_signs_new_la.html
Pennsylvania	§ 123.22. Combustion units Distillate: 500 ppm effective July 1, 2016 Residual: 0.5% effective July 1, 2016 #4 Oil: 0.25% effective July 1, 2016 See: http://www.pacode.com/secure/data/025/chapter123/s123.22.html
Rhode Island	Air Pollution Control Regulations No. 8 Sulfur Content of Fuels Distillate: 500 ppm effective July 1, 2014; 15 ppm effective July 1, 2018 Residual: 0.5% effective July 1, 2018 See: http://www.dem.ri.gov/pubs/regs/regs/air/air08_14.pdf
Vermont	5-221(1) Sulfur Limitations in Fuel Distillate: 500 ppm effective July 1, 2014; 15 ppm effective July 1, 2018 Residual: 0.5% effective July 1, 2018 #4 Oil: 0.25% effective July 1, 2018 See: http://www.epa.gov/region1/topics/air/sips/vt/VT_Section5_221.pdf

Table 4-40. Summary of fuel sulfur rule impacts on SO_2 emissions for 2023en

Year	Emissions Eligible for Control	Controlled (Final) Emissions	Reductions	% Reductions
2023	90,764	10,035	80,729	88.9%

4.2.4.6 Natural gas turbines NO_X NSPS (ptnonipm, pt_oilgas)

Packet:
"CONTROL_2011v6.2_2025_NOX_GasTurbines_16dec2014_v0.txt"
"BETA_Controls_GasTurbines_NSPS_2023_30jul2016.csv" (MARAMA)

These 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 NOx 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 SIP (State Implementation Plan) Call, which required affected gas turbines to reduce their NOx emissions by 60 percent.

Table 4-41 compares the 2006 NSPS emission limits with the NOx RACT regulations in selected states within the NOx SIP Call region. The map showing the states and partial-states in the NOx SIP Call Program can be found at: http://www3.epa.gov/airmarkets/progress/reports/program_basics.html. We assigned only those counties in Alabama, Michigan and Missouri as NOx SIP call based on the map on page 8. The state NOx

RACT regulations summary (Pechan, 2001) is from a year 2001 analysis, so some states may have updated their rules since that time.

Table 4-41. Stationary gas turbines NSPS analysis and resulting emission rates used to compute controls

NOx Emission Limits for New Stationary Combustion Turbines				
Firing Natural Gas	**<50 MMBTU/hr**	**50-850 MMBTU/hr**	**>850 MMBTU/hr**	
Federal NSPS	100	25	15	ppm
State RACT Regulations	**5-100 MMBTU/hr**	**100-250 MMBTU/hr**	**>250 MMBTU/hr**	
Connecticut	225	75	75	ppm
Delaware	42	42	42	ppm
Massachusetts	65*	65	65	ppm
New Jersey	50*	50	50	ppm
New York	50	50	50	ppm
New Hampshire	55	55	55	ppm
* Only applies to 25-100 MMBTU/hr				
Notes: The above state RACT table is from a 2001 analysis. The current NY State regulations have the same emission limits.				
	New source emission rate (Fn)		**NOx ratio**	**Control (%)**
NOx SIP Call states plus CA	= 25 / 42 =		0.595	40.5%
Other states	= 25 / 105 =		0.238	76.2%

Regarding stationary gas turbine lifetimes, the IPM financial modeling documentation lists the book life of combustion turbines as 30 years, with a debt life of 15 years, and a U.S. MACRS Depreciation Schedule of 15 years (EPA, 2013). This same documentation lists the book life of nuclear units at 40 years. IPM uses a 60-year lifetime for nuclear units in its simulations of unit retirements. Using the same relationship between estimated lifetime and book life for nuclear units of 1.5, the estimated lifetime for a combustion turbine would be 45 years. This is the same as an annual retirement rate of 2.2 percent.

For projection 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 NO_x 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 2* (see Section 4.2.4) as a function of the year-specific projection factor. Resulting controls greater than or equal to 1 percent were included in our projections. National Process Heaters

NSPS reductions from projected pre-NSPS 2023 inventory are shown in Table 4-42. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-42. National by-sector 2023en NO_X reductions from Stationary Natural Gas Turbine NSPS controls

Sector	**Pre-NSPS Emissions**	**NSPS Reductions**	**NSPS % Reductions**
Non-EGU Point (ptnonipm)	15,109	4,070	27%
Point Oil & Gas (pt_oilgas)	74,020	23,448	32%
Total	89,129	27,518	31%

4.2.4.7 Process heaters NO_X NSPS (ptnonipm, pt_oilgas)

Packet:
"CONTROL_2011v6.2_2025_NOX_Process_heaters_09dec2014_v0.txt"
"BETA_Controls_ProcessHeaters_NSPS_2023_30jul2016.csv" (MARAMA)

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 NOx and SO_2.

In 2011, 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 4-43.

In order to develop a relationship between the typical process heater emission rates in 2011 compared with what the NSPS will require of new and modified sources, an analysis of the materials in the EPA docket (EPA-HQ-OAR-2007-0011) for the NSPS was performed. This docket contained an EPA memorandum that estimated the NOx emissions impacts for process heaters. Table 1 in that memo titled, "Summary of Representative Baseline NOx Concentrations for Affected Process Heaters," analysis can be used to establish an effective 2011 process heater NOx emission rate, although the information that EPA used in the revised NOx impact estimates probably uses data from a few years before 2011. It is likely that the data used are representative of 2011 emissions because the only wide-ranging program that has affected process heater emission rates recently have been consent decrees, and the emission reductions associated with these agreements should have been achieved before 2011. However, the compliance schedules are company-specific, and differ by company, so it is difficult to make overarching conclusions about when compliance occurred.

Table 4-43. Process Heaters NSPS analysis and 2011v6.2 new emission rates used to compute 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**

The EPA states that because it "does not have much data on the precise proportion of process heaters that are forced versus natural draft, so the nationwide impacts are expressed as a range bounded by these two scenarios." (Scenario 1 assumes all of the process heaters are natural draft process heaters and Scenario 2 assumes all of the process heaters are forced draft process heaters.)

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 2* (see Section 4.2.4) as a function of the year-specific projection factor. Resulting controls greater than or equal to 1 percent were retained. National Process Heaters NSPS reductions from projected pre-NSPS 2023 inventory are shown in Table 4-44. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-44. National by-sector NO_X reductions from Process Heaters NSPS controls for 2023en

Sector	Pre-NSPS Emissions	NSPS Reductions	NSPS % Reductions
Non-EGU Point (ptnonipm)	72,798	20,151	28%
Point Oil & Gas (pt_oilgas)	7,352	1,828	25%
Total	80,149	21,979	27%

4.2.4.8 Arizona regional haze controls (ptnonipm)

Packet:

"CONTROL_2011v6.2_20xx_AZ_Regional_Haze_PT_24feb2015_v0.txt"

U.S. EPA Region 9 provided regional haze FIP controls for a few industrial facilities. Information on these controls are available in the *Federal Register* (EPA-R09-OAR-2013-0588; FRL-9912-97-OAR) at http://www.federalregister.com. These non-EGU controls have implementation dates between September 2017 and December 2018 and, therefore, do not reduce emissions in year 2017 projections. Year 2025 emissions are reduced at 5 smelter and cement units: NOx by 1,722 tons and SO_2 by 26,423 tons.

4.2.4.9 CISWI (ptnonipm)

Packet:

"CONTROL_CISWI_2011v6_22nov2013_v0.txt"

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 re-development 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 2011 NEI inventory and because the baseline CISWI emissions and the 2011 NEI emissions were not the same, the EPA computed percent reductions such that our future year emissions matched the CISWI controlled dataset values. CISWI controls are applied in Arkansas and Louisiana only, totaling 3,100 and 3,552 tons of SO_2 reductions in years 2017 and 2025 respectively. The reductions are greater in year 2025 because they are applied to year-specific projected (grown) emissions.

4.2.4.10 Petroleum Refineries: NSPS Subpart Ja (ptnonipm)

Packets:

"CONTROL_2011v6_3_2017_NSPS_Subpart_JA_07aug2017_v0"

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 implemented in the 2023en case in a CONTROL packet (CONTROL_2011v6_3_2017_NSPS_Subpart_JA_07aug2017_v0) that was applied to petroleum refineries in the ptnonipm sector. Table 4-39 below reflects the impacts of these NSPS controls on the ptnonipm sector.

Table 4-45. National emissions reductions from Petroleum Refineries NSPS controls for 2023en.

Year	Pollutant	Emissions Eligible for Control	Controlled (Final) Emissions	Reductions (tons)	% Reductions
NOX	2023	10,353	7,696	2,657	26%
SO2	2023	24,709	14,896	9,813	40%
VOC	2023	3,731	682	3,049	82%

4.2.4.11 Data from comments on previous platforms and recent comments (nonpt, ptnonipm, pt_oilgas)

Packets:

"CONTROL_2011v6.2_20xx_State_comments_2018docket_nonpt_15jan2015_v0.txt"
"CONTROL_2011v6_2_20xx_CD_St_com_2018docket_pt_15jan2015_fixed_01sep2015_v0.txt"
"BETA_Controls_STATE_RULES_AND_CONSENT_DECREES_2016_08_11.csv" (MARAMA)
"BETA_Controls_OTC_RULES_2016_08_13.csv" (MARAMA)

All remaining non-EGU point and nonpoint controls are discussed in this section. For the nonpoint sector, these controls are limited to comments/data-responses on the previous emissions modeling platforms, and the 2018 NODA process. For point sources, controls include data from the 2018 NODA process as well as a concatenation of all remaining controls not already discussed. These controls are split into separate packets for point and nonpoint sources.

Nonpoint packet: (CONTROL_2011v6.2_20xx_State_comments_2018docket_nonpt_15jan2015_v0.txt)
This packet contains all nonpoint controls not already discussed in previous sections (e.g., Fuel Sulfur rules, ICI boilers) provided in response to the 2018 NODA, and is restricted to VOC controls for Delaware, Massachusetts, Pennsylvania and Virginia, with the great majority of these controls restricted to Virginia. These VOC controls cover various state programs and rules such as auto refinishing, adhesives and surface coatings. Cumulatively, these VOC controls reduce nonpoint VOC by approximately 3,900 tons in 2017 and 4,100 tons in 2025.

Point packet: CONTROL_2011v6_2_20xx_CD_St_com_2018docket_pt_15jan2015_fixed.txt

This packet contains all point controls not already discussed in previous sections (e.g., Fuel Sulfur rules, ICI boilers). This packet includes new controls information provided in response to the 2018 NODA as well as "legacy" controls from the 2011v6.0 emissions modeling platform from numerous sources such as settlement and consent decree data gathering efforts, comments received during the CSAPR rulemaking process, regional haze modeling, and stack-specific control information provided by TCEQ.

New control information from the 2018 NODA responses is primarily limited to VOC controls from several states: Delaware, Massachusetts, New Jersey, Pennsylvania and Virginia. However, we also received comments with revised compliance dates, removal of existing control information, and updated controls from local settlements. The CONTROL packet comments field provides information on the source of new control information, where available.

The “old” control information includes information discussed in previous emissions modeling platforms; these CONTROL packet components are discussed in Section 4.2.9 in the 2011v6.1 emissions modeling platform TSD (EPA, 2014b).

Cumulative ptnonipm and pt_oilgas reductions to 2023 pre-controlled (projection factors already applied) from this CONTROL packet are shown in Table 4-46. This table reflects the impacts of both the MARAMA and non-MARAMA packets. In the August, 2016 data provided by MARAMA, impacts from the Pennsylvania RACT regulations were included. The estimated PA RACT NOx reduction for cement kilns, glass melting, and natural gas transmission was approximately 7700 tons. There were six MWC facilities in Pennsylvania be subject to RACT for a total of 19 units. However, these were not adjusted because all but one were found to alrady be emitting at rates under the applicable NOx RACT limit. The one unit that was found to be above the limit was not adjusted due to its small impact of approximately 6 tons. In addition, note that some of the natural gas transmission sources in Pennsylvania were affected by both RACT and the gas turbine NSPS.

Table 4-46. Summary of remaining nonpt, ptnonipm and pt_oilgas reductions for 2023en

Year	Pollutant	Emissions Eligible for Control	Controlled (Final) Emissions	Reductions	% Reductions
2023	CO	5,554	754	4,799	86%
2023	NH3	213	52	161	76%
2023	NOX	96,249	47,796	48,453	50%
2023	PM10	4,055	1,944	2,111	52%
2023	PM2.5	3,643	1,766	1,877	52%
2023	SO2	122,036	25,357	96,679	79%
2023	VOC	30,031	22,954	7,077	24%

For 2023en, additional reductions to ptnonipm sources were made to account for coal mine trucks in Wyoming getting cleaner in future years. The reductions were based on percent reductions to heavy duty offroad construction trucks and are shown in Table 4-47.

Table 4-47. Reductions in Wyoming coal mine trucks in 2023en

Year	Pollutant	Emissions Eligible for Control	Controlled (Final) Emissions	Reductions	% Reductions
2023	CO	17,238	3,475	13,763	78%
2023	NOX	15,808	8,332	7,477	47%
2023	PM10	1,051	240	811	77%
2023	PM2.5	1,024	234	790	77%
2023	SO2	343	208	134	39%
2023	VOC	190	158	31	17%

4.2.5 Stand-alone future year inventories (nonpt, ptnonipm)

This section discusses future year NEI non-EGU point and nonpoint emission inventories that were not created via CoST strategies/programs/packets. These inventories are either new to the future years because they did not exist in 2011 (e.g., new cement kilns, biodiesel and cellulosic plants), or are a complete replacement to the year 2011 NEI inventory in the case of portable fuel containers. New non-EGU facilities provided by South Carolina via the 2018 NODA on the 2011v6.0 platform were mistakenly omitted from both year 2017 and 2025 emissions modeling processing. Cumulatively, these new facilities would have added approximately 200 tons of NO_x, and under 100 tons of each of the remaining CAPs.

4.2.5.1 Portable fuel containers (nonpt)

Future year inventory: "pfc_2025_2011v6.2_ff10_28jan2015_13sep2016_v2.csv"

The EPA used future-year VOC emissions from Portable Fuel Containers (PFCs) from inventories developed and modeled for EPA's MSAT2 rule (EPA, 2007a). The six PFC SCCs are summarized below (note that the full SCC descriptions for these SCCs include "Storage and Transport; Petroleum and Petroleum Product Storage" as the beginning of the description).

- 2501011011 Residential Portable Fuel Containers: Permeation
- 2501011012 Residential Portable Fuel Containers: Evaporation
- 2501011014 Residential Portable Fuel Containers: Refilling at the Pump: Vapor Displacement
- 2501012011 Commercial Portable Fuel Containers: Permeation
- 2501012012 Commercial Portable Fuel Containers: Evaporation
- 2501012014 Commercial Portable Fuel Containers: Refilling at the Pump: Vapor Displacement

The future-year emissions reflect projected increases in fuel consumption, state programs to reduce PFC emissions, standards promulgated in the MSAT2 rule, and impacts of the RFS2 standards on gasoline volatility. The EPA developed year 2025 PFC emissions that include estimated Reid Vapor Pressure (RVP) and oxygenate impacts on VOC emissions, and more importantly, large increases in ethanol emissions from RFS2. These emission estimates also include gas can vapor displacement, tank permeation and diurnal emissions from evaporation. Because the future year PFC inventories contain ethanol in addition to benzene, the EPA developed a VOC E-profile that integrated ethanol and benzene (see Section 3.2.1.2 of the 2011v6.3 platform TSD for more details). Note that spillage emissions were not projected and were carried forward from 2011. We received projection and control packets from MARAMA in August 2016. We applied these packets to the PFC inventory to obtain year 2023 emissions for the MARAMA states. The names of these packets were the following:

- BETA_Projections_PFC_2023_10aug2016_emf.csv
- BETA_Controls_PFC_28jul2016.csv

A summary of the resulting PFC emissions for 2011 and 2025 (used for 2023) for MARAMA and non-MARAMA states are provided in Table 4-48. Note that for MARAMA states, PFCs were projected from 2011, with separate projections for 2023 and 2028. For non-MARAMA states, the EPA 2025 PFC inventory was used for 2023. Note that the EPA PFC inventory includes ethanol, but MARAMA inventories do not because they were projected from the 2011NEIv2.

Table 4-48. PFC emissions for 2011 and 2023 [tons]

	MARAMA Emissions		Difference	% Change
	2011	2023	2023	2023
VOC	38,152	12,595	-25,557	-67.0%
Benzene	463	474	10	2.3%

	non-MARAMA Emissions		Difference	% Change
	2011	2025	2025	2025
VOC	160,051	46,498	-113,553	-70.9%
Benzene	323	613	290	89.8%
Ethanol	0	3,294	n/a	

4.2.5.2 Biodiesel plants (ptnonipm)

New Future year inventory: "Biodiesel_Plants_2018_ff10"

The EPA's OTAQ developed an inventory of biodiesel plants for 2018. Plant location and production volume data came from the Tier 3 proposed rule[44,45]. The total volume of biodiesel came from the AEO 2013 early release, 1.3 BG for 2018. To reach the total volume of biodiesel, plants that had current production volumes were assumed to be at 100 percent production and the remaining volume was split among plants with planned production. Once facility-level production capacities were scaled, emission factors based on soybean oil feedstock were applied. These emission factors in Table 4-49 are in tons per million gallons (Mgal) and were obtained from the EPA's spreadsheet model for upstream EISA impacts developed for the RFS2 rule (EPA, 2010a). Inventories were modeled as point sources with *Google Earth* and web searching validating facility coordinates and correcting state-county FIPS.

Table 4-49. Emission Factors for Biodiesel Plants (Tons/Mgal)

Pollutant	Emission Factor
VOC	4.3981E-02
CO	5.0069E-01
NO_X	8.0790E-01
PM_{10}	6.8240E-02
$PM_{2.5}$	6.8240E-02
SO_2	5.9445E-03
NH_3	0
Acetaldehyde	2.4783E-07
Acrolein	2.1290E-07
Benzene	3.2458E-08
1,3-Butadiene	0
Formaldehyde	1.5354E-06

[44] U.S. EPA 2014.Regulatory Impact Analysis for Tier 3 Vehicle Emission and Fuel Standards Program. EPA-420-RD-143-0052.
[45] Cook, R. 2014. Development of Air Quality Reference Case Upstream and Portable Fuel Container Inventories for Tier 3 Final Rule. Memorandum to Docket EPA-HQ-OAR-2010-0162.

Table 4-50 provides the 2018 biodiesel plant emissions estimates. Since biofuels were not projected to change significantly between 2018 and 2023 the year 2018 inventory was used for year 2023. Emissions in 2011 are assumed to be near zero, and HAP emissions in 2023 are nearly zero. The emission factor for ethanol is 0.

Table 4-50. 2018 biodiesel plant emissions [tons]

Pollutant	2018
CO	649
NO_X	1048
PM_{10}	89
$PM_{2.5}$	89
SO_2	8
VOC	57

4.2.5.3 Cellulosic plants (nonpt)

New Future year inventories:
Primary inventory: "2018_cellulosic_inventory"
New Iowa inventory: "cellulosic_new_Iowa_plants_from2018docket_2011v6.2_ff10_28jan2015"

Development of primary inventory
Depending on available feedstock, cellulosic plants are likely to produce fuel through either a biochemical process or a thermochemical process. The EPA developed county-level inventories for biochemical and thermochemical cellulosic fuel production for 2018 to reflect AEO2013 energy renewable fuel volumes. Emissions factors for each cellulosic biofuel refinery reflect the fuel production technology used rather than the fuel produced. Emission rates in Table 4-51 and Table 4-52 were used to develop cellulosic plant inventories. Criteria pollutant emission rates are in tons per RIN gallon. Emission factors from the cellulosic diesel work in the Tier 3 NPRM were used as the emission factors for the thermochemical plants. Cellulosic ethanol VOC and related HAP emission factors from the Tier 3 NPRM were used as the biochemical VOC and related HAP emission factors. Because the future year cellulosic inventory contains ethanol, a VOC E-profile that integrated ethanol was used; see Section 3.2 of the 2011v6.3 platform TSD for more details.

Plants were treated as area sources spread across the entire area of whatever county they were considered to be located in. Cellulosic biofuel refinery siting was based on utilizing the lowest cost feedstock, accounting for the cost of the feedstock itself as well as feedstock storage and the transportation of the feedstock to the cellulosic biofuel refinery. The total number of cellulosic biofuel refineries was projected using volumes from AEO2013 (early release). The methodology used to determine most likely plant locations is described in Section 1.8.1.3 of the RFS2 RIA (EPA, 2010a). Table 4-53 provides the year 2018 cellulosic plant emissions estimates that were used in this year 2023 modeling platform.

Table 4-51. Criteria Pollutant Emission Factors for Cellulosic Plants (Tons/RIN gallon)

Cellulosic Plant Type	VOC	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	NH_3
Thermochemical	5.92E-07	8.7E-06	1.31E-05	1.56E-06	7.81E-07	1.17E-06	1.44E-10
Biochemical	1.82E-06	1.29E-05	1.85E-05	3.08E-06	1.23E-06	6.89E-07	0

Table 4-52. Toxic Emission Factors for Cellulosic Plants (Tons/RIN gallon)

Plant Type	Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	Formaldehyde	Ethanol
Thermochemical	2.95E-08	1.27E-09	9.61E-10	0	5.07E-09	2.09E-07
Biochemical	3.98E-07	1.11E-08	1.39E-08	0	2.28E-08	6.41E-07

Table 4-53. 2017 cellulosic plant emissions [tons]

Pollutant	Emissions
Acrolein	1
Formaldehyde	3
Benzene	0
Acetaldehyde	15
CO	4,435
Ethanol	106
NH_3	0
NO_X	6,702
PM_{10}	793
$PM_{2.5}$	398
SO_2	596
VOC	302

Development of new Iowa inventory

The Iowa DNR (Department of Natural Resources), via the 2018 NODA comments (see docket # EPA-HQ-OAR-2013-0809 under http://www.regulations.gov), provided information on new cellulosic ethanol capacity information for three facilities. Emissions for these facilities were computed using the emission factors previously discussed in Table 4-51 and Table 4-52. The resulting new facilities and NOx emissions, used for year 2023 are provided in Table 4-54. Note that these facilities are in a nonpoint inventory because latitude-longitude coordinates were not available.

Table 4-54. New cellulosic plants NOx emissions provided by Iowa DNR**.**

FIPS	County	Facility Name	Approximate Production Capacity (Mgal/yr)	NO_X Emissions
19093	Ida	Quad County Corn Processors' Adding Cellulosic Ethanol (ACE)	2	26
19147	Palo Alto	POET-DSM Project Liberty	25	329
19169	Story	DuPont Cellulosic Ethanol	30	394

4.2.5.4 New cement plants (nonpt)

Nonpoint Inventories: “cement_newkilns_year_2025_from_ISIS2013_NEI2011v1_NONPOINT_v0.csv”

As discussed in Section 4.2.3.7, the ISMP model, was used to project the cement manufacturing sector to future years. This section covers new ISMP-generated kilns that did not exist in the 2011 NEI. For kilns that were new in 2018, the EPA used two different approaches for modeling. The ISMP model created “generic” kilns in specific geographically strategic locations (counties) to cover the need for increased production/capacity in future years. Because these generic kilns are not permitted and the location in these counties is uncertain, these are modeled at the county-level to avoid placing new large modeled emissions sources into one grid cell. These nonpoint source kilns were then spatially allocated based on industrial land activity in the county.

For all ISMP future year emissions, PM_{10} is assigned as 0.85 of total PM provided by ISMP, and $PM_{2.5}$ is assigned as 0.15 of total PM. New ISMP-generated kilns are assigned as Precalciner kilns (SCC=30500623). While ISMP provides emissions for mercury, the EPA did not retain these in our modeling. Table 4-55 shows the magnitude of the new ISMP-based cement kilns. ISMP-generated kilns as nonpoint sources only.

Table 4-55. ISMP-generated nonpoint cement kiln emissions

Pollutant	Nonpoint Emissions
NO_X	10,255
$PM_{2.5}$	23
SO_2	5,311
VOC	250

4.2.5.5 New units from states (ptnonipm)

The State of Wisconsin Department of Natural Resources and MARAMA provided comments on the NODA for the 2011v6.3 platform that included the suggestion of new units for the ptnonipm sector that will be running by the year 2023 for the states of Wisconsin, Delaware, and West Virginia. The units listed in Table 4-56 have been incorporated into this platform.

File: “2023en_ptnonipm_new_units_state_comments_DE_WV_WI_09aug2017_v0.csv”

Table 4-56. New Non-EGU Point Units for 2023

Facility name	EIS Facility ID	EIS Unit IDs
Ameresco Delaware Energy-Central	16812111	113545813
Ameresco Delaware Energy-Southern	16810211	108718913
CRODA INC.	588911	108721913
PPG Industries, INC., Natrium Plant	4878711	71796413
Union Carbide Corporation	6884411	UCCI_B016, UCCI_B017, UCCI_B018, UCCI_B019, UCCI_B020

Facility name	EIS Facility ID	EIS Unit IDs
Williams Ohio Valley Midstream - Fort Beeler Gas Processing Plant	16886211	110325313, 110325513, 110325613, 110325713, 110325813, 110325913, 110326113, 110326213, 110326413, 110326513, 110326613, 110326713, 110326813, 110326913, 110327013, 110327113, 110327213, 110327313, 110327413
Armstrong World Industries - Millwood Facility	16886111	110321113, 110321313, 110321413, 110321513, 110321613, 110321713, 110321813, 110321913, 110322013, 110322113, 110322213
Williams Ohio Valley Midstream - Moundsville Fractionation Plant	16886311	110327513, 110327813, 110327913, 110328013
Marathon Petroleum - Neal Propane Cavern	16886611	110333413, 110333513, 110333613
Williams Ohio Valley Midstream - Moundsville Fractionation Plant	16886311	110327613, 110327713
Marathon Petroleum - Butane Cavern	16886511	110333113, 110333213, 110333313
Georgia-Pacific Consumer Products LP	4944011	113709613
Proctor & Gamble Paper Products CO	4943711	125438213
Packaging Corporation of America-Tomahawk	4985811	113802813
Expera Specialty Solutions INC	4943911	122251813

4.3 Mobile source projections

Mobile source monthly inventories of onroad and nonroad mobile emissions were created for 2023 using a combination of the MOVES2014a and the NMIM models. The 2023 onroad emissions account for changes in activity data and the impact of on-the-books rules including some of the recent regulations such as the Light Duty Vehicle GHG Rule for Model-Year 2017-2025, and the Tier 3 Motor Vehicle Emission and Fuel Standards Rule (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-motor-vehicles-tier-3). 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. Table 4-1 provides references to many of these programs.

Nonroad mobile emissions reductions for these years include reductions to various nonroad engines such as diesel engines and recreational marine engine types (pleasure craft), fuel sulfur content, and evaporative emissions standards.

Onroad mobile sources are comprised of several components and are discussed in Section 4.3.1. Monthly nonroad equipment mobile emission projections are discussed in Section 4.3.2. Locomotives and CMV projections were discussed in Section 4.2.3.3.

4.3.1 Onroad mobile (onroad)

The onroad emissions for 2023 use the same SMOKE-MOVES system as for the base year (see Section 2.1). Meteorology, speed, spatial surrogates and temporal profiles, representative counties, and fuel months were the same as for 2011. For the 2011v6.3 platform, the EPA developed activity data and emissions factors directly for 2023.

4.3.1.1 Future activity data

Estimates of total national VMT in 2023 came from AEO 2016 (https://www.eia.gov/outlooks/aeo/) transportation projections. Trends were developed by calculating ratios between 2017 AEO and 2023 AEO[46] estimates and applying the trends to the 2017 VMT from the 2011v6.3 emissions platform. In states for which we received 2018 VMT for use in the 2011v6.2 and 2011v6.3 emissions platforms, 2018 state-submitted VMT was projected using AEO trends from 2018 to 2023, rather than from 2017 to 2023. These ratios were developed for light versus heavy duty and for four fuel types: gasoline, diesel, E-85, and CNG. The projection factors, the national 2017 VMT from the 2011v6.3 platform ("VMT 2017") by broad vehicle and fuel type, and the default future VMT ("VMT 2023") are shown in Table 4-57. Note that where states provided 2018 VMT, the 2023 VMT does not exactly equal the 2017 VMT times the ratio.

Table 4-57. Projection factors for 2023 (in millions of miles)[47]

Classification	MOVES source types	VMT 2017	Ratio 2023	VMT 2023
LD gas	11,21,31,32	2,894,984	1.02357	2,958,777
HD gas	42,43,51,52,53,54	22,600	1.10173	25,018
HHD gas	61	835	1.83151	1,528
LD diesel	21,31,32	93,339	2.33508	212,725
HD diesel	41,42,43,51,52,53,54	73,374	1.10235	80,857
HHD diesel	61,62	151,984	1.05092	159,783
Bus CNG	42	480	1.00496	487
LD E-85	21,31,32	14,784	1.16852	17,245
Total	N/A	3,252,378	N/A	3,456,420

In the above table, light duty (LD) includes passenger cars, light trucks, and sometimes motorcycles, heavy duty (HD) includes buses and single unit trucks, and heavy-heavy duty (HHD) includes combination trucks. The specific MOVES source type codes are listed above. These national SCC6 ratios were applied to the 2017ek VMT to create an EPA estimate of 2023 VMT at the county, SCC level.

Two additional steps were incorporated into the VMT projections. First, a set of states provided 2018 VMT projections for use in the 2011v6.2 and 2011v6.3 emissions platforms: Alabama, Connecticut, Georgia, Maine, Maryland, Massachusetts, Michigan, Missouri, Nevada, New York, New Jersey, North Carolina, Utah,

[46] By "2017 AEO" and "2023 AEO," this refers to the AEO2016's estimates of national VMT in those specific calendar years.
[47] Note: The LD ratios were further adjusted to take into account of high vs low growth of human population (discussed below). On average, the LD ratios match those in this table. For the actual VMT, see the inventory packaged with the cases. In addition, areas for which we incorporated state-submitted VMT for 2018 into the 2011v6.3 emissions platform were projected from 2018 to 2023, rather than from 2017.

Vermont, Virginia, and Wyoming[48]. For these states, 2018 VMT was projected to 2023 using AEO2016-based trends from 2018 to 2023, similarly to how the rest of the country was projected using AEO2016-based trends from 2017 to 2023. This was done so that the 2018-to-2017 backcasting performed in the 2011v6.3 emissions platform, which is based on older AEO estimates (AEO2014), would not affect these new 2023 projections. Second, the EPA adjusted the national LD ratios so that it would reflect regional differences in growth rate. The EPA analyzed LD VMT and corroborated that it had a high correlation with human population. Therefore, if a region has strong human population growth in the future, it will likely have larger VMT growth than the national average. To take account of this spatial difference in growth, the EPA used human population to adjust the national LD VMT growth rate so that on average the growth rate matched the national average, but any specific county growth rate was adjusted by the human population growth for that county:

$$VMTprojFactor_{sc} = AEOprojFactor_{s} * (1 + D(\left(\frac{humanProjFactor_{c}}{natlhumanProjFactor}\right) - 1))$$

where

- s = source type/fuel
- c = county
- VMTprojFactor = county VMT projection factor (by source/fuel)
- AEOprojFactor = national VMT projection factor from AEO (by source/fuel)
- humanProjFactor = human projection factor for the county (year specific)
- natlhumanProjFactor = national human projection factor (year specific)
- D = damping factor, 0 = no county adjustment, 1 = full county variation

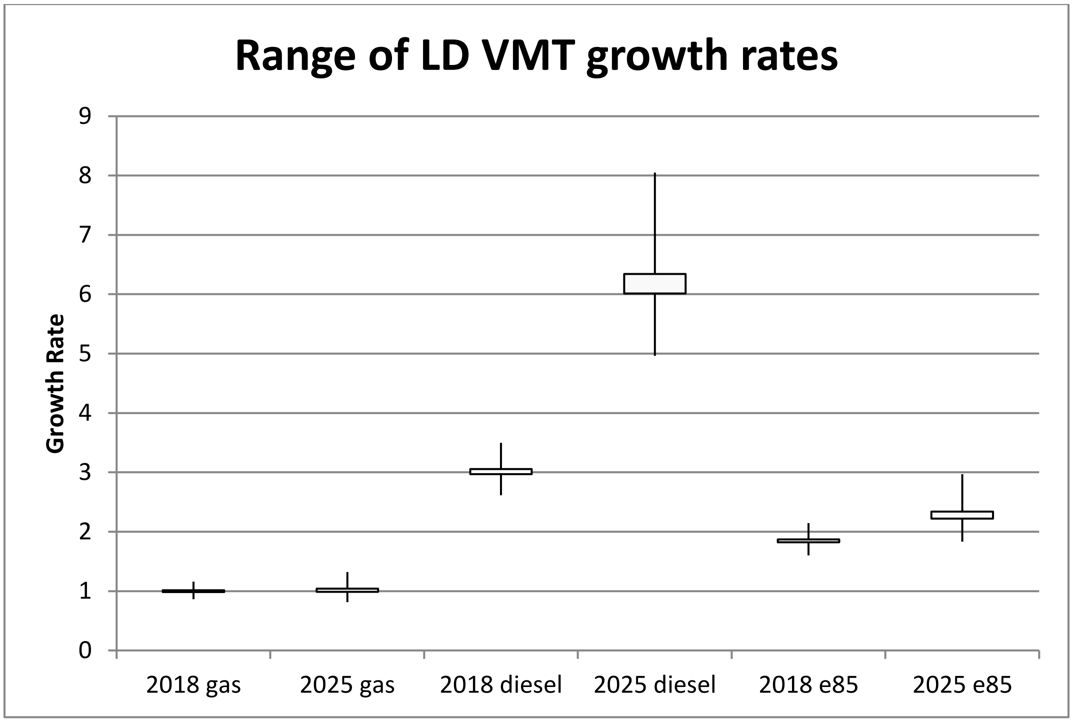
The specific value of D used for EPA projections was 0.5. This was based on an analysis of the growth of LD vehicles over time as compared to human population, which was found to be about 0.5 vehicles per person. The LD growth rates will vary by county, fuel, and year. The range of these growth rates are shown in Figure 4-3.

Vehicle population (VPOP) was developed by creating VMT/VPOP ratios from the 2011NEIv2 VMT and 2011NEIv2 VPOP at the county, fuel and vehicle type (SCC6) level. These ratios were applied to the 2023 VMT to create a 2023 VPOP.

Hoteling (HOTELING) was developed by creating VMT/HOTELING ratios from the 2011 NEIv2 VMT and 2011 NEIv2 HOTELING at the county level. For these ratios, the VMT was limited to combination long-haul trucks (SCC6 220262) on restricted access roads. The HOTELING was the total of auxiliary power units (APU) and extended idle (EXT). These ratios were applied to the 2023 VMT to create a 2023 HOTELING. To get the APU split, 22.62 percent of HOTELING was assumed to be APU in all counties. This is consistent with MOVES2014a default splits for APU for calendar years 2017 and 2025, interpolated to 2023.

[48] For many of these states, we used the county total from the state data and distributed those totals to EPA's SCCs based on default projected VMT. For Michigan, SEMCOG provided the Detroit projections and the rest of the counties came from the state. For Missouri, the state provided the 5 counties around St Louis. For Nevada, the EPA received projections only for Clark County. For Georgia, the state agreed with our default projection method but they wanted to use Georgia-provided human population projections for distributing the LD VMT growth rates to counties. They provided the human population for the 21 Atlanta counties. For the remaining counties, Georgia asked to use EPA defaults.

Figure 4-3. Light Duty VMT growth rates based on AEO2014



4.3.1.2 Set up and run MOVES to create emission factors

Emission factor tables were created by running SMOKE-MOVES using the same procedures and models as described for 2011 (see the 2011NEIv2 TSD and Section 2.1). The same meteorology and the same representative counties were used. Changes between 2011 and future years (2023) are predominantly due to activity data, fuels, national and local rules, and age distributions. Age (i.e., model year) distributions were projected forward using the methodology described in the MOVES activity report (EPA, 2016c), although some states supplied age distributions in their CDBs. Fleet turnover resulted in a greater fraction of newer vehicles meeting stricter emission standards. The similarities and differences between the two runs are described in Table 4-58.

Table 4-58. Inputs for MOVES runs for 2023

Element	2023 MOVES Inputs
Code	MOVES20151201 (MOVES2014a)
Rep. county database	285RepCos2023_M2014_20160520
Default database	movesdb20151028
VMT and VPOP	2023el
Hydrocarbon speciation	CB6v2 done inside MOVES
Fuels	M2014a_fuelsupply AND regioncountytrnoda_20151203
CA LEVIII	ca_standards_SS_20140903 (16 states)

The following states were modeled as having adopted the California LEV III program (see Table 4-59):

Table 4-59. CA LEVIII program states

FIPS	State Name
06	California
09	Connecticut
10	Delaware
23	Maine
24	Maryland
25	Massachusetts
34	New Jersey
36	New York
41	Oregon
42	Pennsylvania
44	Rhode Island
50	Vermont
53	Washington

Fuels were projected into the future using estimates from the AEO2014 (http://www.eia.gov/forecasts/aeo/), release date May 7^{th} 2014, as well as fuel properties changing as part of the Tier 3 Emissions and Fuel Standards Program (https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-motor-vehicles-tier-3). The AEO2014 projection includes market shares of E10, E15, and E85 in 2018, as well as biodiesel market shares up to B5 (note that these values do not assume full implementation of the RFS2 program). The regional fuel properties and renewable volumes in 2011 were projected to 2018 in order to preserve the regional variation present in these fuel supplies, with total fuel volumes aligned to those in the AEO2014.

4.3.1.3 California and Texas adjustments

A set of adjustments were done in SMOKE-MOVES to create 2023 emissions: 1) refueling, and 2) California and Texas emissions.

The first set of adjustment factors was for refueling. This uses the same approach as was used in 2011 (see the Section 2.1 for details) to account for the few counties in Colorado that provided point source gas refueling emissions. These adjustments essentially zero out the MOVES-based gasoline refueling emissions (SCC 2201*62) in these counties so that the point estimates will be used instead and, thus, refueling emissions will not be double-counted.

The second set of adjustment factors was used to incorporate future year emissions provided by California. The same approach as was used in 2011 was used to match the emissions totals provided by CARB. The only differences between the 2011 approach and that applied for 2023 are that the latter uses the 2023 emissions provided by CARB and the 2023 EPA SMOKE-MOVES output to apportion and temporalize the emissions.

The third set of adjustment factors was meant to incorporate emissions provided by Texas. Conceptually, the EPA used the trend of 2017 to 2023 based on the EPA's estimates to project Texas' submitted emissions for 2017. Mathematically, this is equivalent to taking the Texas adjustment factors derived for 2017 and applying them directly to EPA's 2023 run.

4.3.2 Nonroad Mobile Source Projections (nonroad)

The projection of locomotive and CMV emissions to 2023 is described in Section 4.2.3.3. Most of the remaining sources in the nonroad sector are projected by running the NMIM model with fuels and vehicle populations appropriate to 2023; this section describes the projection of these sources.

The nonroad sector includes monthly exhaust, evaporative and refueling emissions from nonroad engines (not including commercial marine, aircraft, and locomotives) derived from NMIM for all states except California and Texas. NMIM provides nonroad emissions for VOC by three emission modes: exhaust, evaporative and refueling.

With the exception of California and Texas, U.S. emissions for the nonroad sector (defined as the equipment types covered by the NONROAD model) were created using a consistent NMIM-based approach as was used for 2011. Specifically, NMIM version 20090504 utilized NONROAD2008a including future-year equipment population estimates, control programs to the year 2023, and inputs were either state-supplied as part of the 2011NEIv1 and 2011NEIv2 process or national level inputs. Fuels for 2023 were assumed to be E10 everywhere for nonroad equipment. The databases used in the 2023 run were NMIM county database "NCD20160627_nei2023v1" and fuels for the year 2023. The 2023 emissions account for changes in activity data (based on NONROAD model default growth estimates of future-year equipment population) and changes in fuels and engines that reflect implementation of national regulations and local control programs that impact each year differently due to engine turnover.

The version of NONROAD used was the current public release, NR08a, which models all in-force nonroad controls. The represented rules include:

- "Clean Air Nonroad Diesel Final Rule - Tier 4", published June, 2004: https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-emissions-air-pollution-nonroad-diesel.
- Control of Emissions from Nonroad Large Spark-Ignition Engines, and Recreational Engines (Marine and Land-Based), November 8, 2002 ("Pentathalon Rule").
- Small Engine Spark Ignition ("Bond") Rule, October, 2008: https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-emissions-small-equipment-tools.

Not included are voluntary local programs such as encouraging either no refueling or evening refueling on Ozone Action Days.

California and Texas nonroad emissions

Similar to the 2011 base year nonroad mobile, NMIM was not used to generate future-year nonroad emissions for California. The CARB-supplied 2023 nonroad annual inventories, which included all CAPs including NH_3, were distributed to monthly emissions values by using monthly temporal profiles assigned by SCC. This is a change from future year California nonroad inventories in prior emissions platforms, in which NMIM monthly inventories were used to compute monthly ratios by county, SCC7, mode and pollutant. See Section 3.2 of the 201v6.3 TSD for details on speciation of California nonroad data. The CARB nonroad emissions include nonroad rules reflected in the December 2010 Rulemaking Inventory (http://www.arb.ca.gov/regact/2010/offroadlsi10/offroadisor.pdf) and those in the March 2011 Rule Inventory, the Off-Road Construction Rule Inventory for "In-Use Diesel."

For Texas, the EPA combined Texas' submitted estimates for 2011 with EPA projections of nonroad emissions into 2023. The EPA used the trend of 2011 to 2023 based on EPA's estimates to project Texas' submitted emissions for 2011. The projections were based on state-wide SCC7, mode, poll ratios[49] of 2023 NMIM to 2011 NMIM. These ratios were then applied to Texas' submitted 2011 nonroad emissions, which had already been distributed to a monthly inventory to create 2023 monthly nonroad inventories. Please refer to the 2011v6.3 TSD (EPA, 2016) for more information on the year 2011 data obtained from Texas.

4.4 Projections of "Other Emissions": Offshore Category 3 Commercial Marine Vessels and Drilling Platforms, Canada and Mexico (othpt, othar, and othon)

As described in Section 2.5, emissions from Canada, Mexico, and drilling platforms are included as part of three emissions modeling sectors: othpt, othar, and othon. For oil drilling platforms, the EPA used emissions from the 2011NEIv2 point source inventory for 2011 and both future years. The Canadian onroad (othon) and nonroad emissions in othar sector for the 2023en case consisted of year 2025 inventory dataset acquired from Environment Canada (see Tables 5-11 and 5-12). The Canadian point sources in for the othpt sector consisted of year 2025 inventory dataset acquired from Environment Canada (see Table 5-13). Area, nonroad, and point emissions for Mexico are based on the Inventario Nacional de Emisiones de Mexico, 2008 projected to years 2018 and 2025, then interpolated to 2023 (ERG, 2014a). Onroad emissions for Mexico are based on run of MOVES-Mexico for 2023 (ERG, 2016).

[49] These ratios were initially attempted by county/SCC7/mode/pollutant, but due to significantly different distributions of certain source types between the EPA and TCEQ's emissions, this created unreasonable growth in certain areas. The above approach was used except in the following, relatively limited conditions. If a state/SCC7/mode/pollutant was in the EPA's 2023 emissions but not in the EPA's 2011 emissions; 2023 EPA emissions were used in the final inventory. If a state/SCC7/mode/pollutant was in TCEQ's 2011 emissions but was not in EPA's 2023 emissions, then state/SCC3/mode/pollutant ratios were used to project to 2023.

5 Emission Summaries

The following tables summarize emissions differences between the 2011 evaluation case and the 2023 base case. These summaries are provided at the national level by sector for the contiguous U.S. and for the portions of Canada and Mexico inside the smaller 12km domain (12US2) discussed in Section 0. The afdust sector emissions represent the summaries *after* application of both the land use (transport fraction) and meteorological adjustments; therefore, this sector is called "afdust_adj" in these summaries. The onroad sector totals are post-SMOKE-MOVES totals, representing air quality model-ready emission totals, and include CARB emissions for California and TCEQ emissions for Texas. The cmv sector includes U.S. emissions within state waters only; these extend to roughly 3-5 nautical miles offshore and includes CMV emissions at U.S. ports. "Offshore to EEZ" represents CMV emissions that are within the (up to) 200 nautical mile EEZ boundary but are outside of U.S. state waters along with the offshore oil platform emissions from the NEI. Finally, the "Non-US SECA C3" represents all non-U.S. and non-Canada emissions outside of the (up to) 200nm offshore boundary, including all Mexican CMV emissions. Canadian CMV emissions are included in the othar sector.

National emission totals by air quality model-ready sector are provided for all CAP emissions for the 2011 evaluation case in Table 5-1. The total of all sectors in the 2011 evaluation case are listed as "Con U.S. Total." Table 5-2 provides national emissions totals by sector for CAPs in the 2023 base case.

Table 5-3 provides national-by sector emission summaries for CO for the 2011 evaluation case and 2023 base case, along with percent change from 2011 to 2023. Table 5-4 through Table 5-9 provide the same summaries for NH_3, NOx, $PM_{2.5}$, PM_{10}, SO_2 and VOC, respectively. Note that the same fire emissions are used in all cases. Tables 5-10 through Table 5-12 provide summaries of the Canadian emissions for the entire country used in the 2011 and 2023 base cases for onroad, area, and point source emissions. Tables 5-13 through Table 5-15 provide summaries of the Mexican emissions for the entire country used in the 2011 and 2023 base cases for onroad, area, and point source emissions

Table 5-1. National by-sector CAP emissions summaries for the 2011 evaluation case

Sector	CO	NH_3	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC
afdust_adj				6,732,941	923,590		
ag		3,515,198					
agfire	1,030,817	3,321	46,035	152,837	101,379	17,755	80,540
cmv_c1c2	58,543	167	288,726	9,712	9,294	6,217	7,696
cmv_c3	11,955	65	125,374	9,946	8,829	84,992	4,888
nonpt	1,645,989	94,242	720,454	491,825	404,258	276,332	3,671,322
np_oilgas	635,942	0	667,068	17,784	16,333	17,232	2,482,590
nonroad	13,951,020	2,627	1,630,301	162,417	154,657	4,031	2,024,419
onroad	25,981,557	120,859	5,708,150	326,900	188,925	28,195	2,713,181
ptfire	20,562,697	329,330	333,398	2,171,987	1,844,263	165,773	4,688,094
ptegu	792,414	25,066	2,096,058	283,066	208,122	4,670,713	38,060
ptnonipm	2,297,549	66,048	1,212,616	477,328	320,816	1,049,374	800,815
pt_oilgas	235,162	5,947	509,856	14,585	13,935	66,577	164,098
rail	122,703	347	791,381	25,898	23,963	7,936	40,851
rwc	2,517,844	19,693	34,436	381,476	381,252	8,954	442,541
Con U.S. Total	**69,844,194**	**4,182,911**	**14,163,853**	**11,258,702**	**4,599,616**	**6,404,080**	**17,159,096**
Offshore to EEZ	176,338	188	904,453	26,401	24,692	139,270	81,713
Non-US SECA C3	16,191	0	191,001	16,228	14,930	120,316	6,878
Canada othafdust				1,192,039	242,374		
Canada othar	2,038,390	338,056	376,758	288,021	157,205	33,464	776,733
Canada othon	1,507,754	6,326	332,349	15,107	5,014	1,270	138,319
Canada othpt	512,629	11,390	231,609	51,137	25,784	522,537	166,284
Canada ptfire_mxca	798,710	13,037	14,048	87,398	73,401	6,481	194,844
Mexico othar	186,575	168,840	183,383	90,691	42,623	10,184	420,637
Mexico othon	1,476,625	2,154	363,342	8,788	3,254	4,432	136,891
Mexico othpt	153,387	3,945	333,368	59,325	45,963	471,847	57,090
Mexico ptfire_mxca	736,810	13,583	31,403	104,125	87,025	6,394	172,196
Non-US Total	**7,603,409**	**557,519**	**2,961,713**	**1,939,261**	**722,265**	**1,316,195**	**2,151,585**

* “Offshore to EEZ” includes both the offshore point emissions, and the “Offshore to EEZ” c3marine emissions.

Table 5-2. National by-sector CAP emissions summaries for the 2023 base case

Sector	CO	NH_3	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC
afdust_adj				7,498,365	1,009,616		
ag		3,602,039					
agfire	1,030,817	3,321	46,035	152,837	101,379	17,755	80,540
cmv_c1c2	57,696	170	175,059	5,387	5,155	1,987	5,241
cmv_c3	18,569	65	105,567	2,126	1,884	4,824	7,639
nonpt	1,682,696	94,695	733,016	509,892	427,719	96,043	3,452,177
np_oilgas	690,025	0	670,895	24,780	21,786	49,707	2,966,396
nonroad	12,627,798	3,228	856,831	84,153	78,858	2,380	1,177,147
onroad	11,300,137	82,106	1,786,856	232,752	79,527	12,114	987,796
ptfire	20,562,697	329,330	333,398	2,171,987	1,844,263	165,773	4,688,094
ptegu	598,510	29,691	1,051,725	173,057	138,932	1,335,974	32,702
ptnonipm	2,271,136	64,691	1,156,792	473,720	320,641	731,219	782,504
pt_oilgas	231,798	5,917	424,595	15,508	14,847	64,990	177,353
rail	145,627	376	563,382	14,236	13,165	340	21,384
rwc	2,368,934	18,499	34,918	362,897	362,651	7,908	415,748
Con U.S. Total	**53,586,440**	**4,234,128**	**7,939,069**	**11,721,698**	**4,420,423**	**2,491,013**	**14,794,722**
Offshore to EEZ	205,146	188	716,768	9,630	9,125	11,615	92,462
Non-US SECA C3	27,845	0	266,129	10,232	9,371	69,507	11,821
Canada othafdust				1,353,416	270,071		
Canada othar	2,192,418	338,711	238,830	284,898	151,849	22,783	800,300
Canada othon	877,268	5,098	141,282	5,520	5,025	549	47,883
Canada othpt	636,056	15,412	221,980	57,514	31,196	409,282	186,100
Canada ptfire_mxca	798,710	13,037	14,048	87,398	73,401	6,481	194,844
Mexico othar	217,518	167,660	212,147	95,486	46,311	12,159	505,017
Mexico othon	1,543,506	2,853	376,485	9,581	4,586	6,370	143,725
Mexico othpt	199,007	5,669	376,422	71,542	54,940	361,230	80,922
Mexico ptfire_mxca	736,810	13,583	31,403	104,125	87,025	6,394	172,196
Non-US Total	**7,434,284**	**562,210**	**2,595,494**	**2,089,342**	**742,899**	**906,371**	**2,235,269**

Table 5-3. National by-sector CO emissions (tons/yr) summaries and percent change

Sector	2011 CO	2023 CO	% change 2011 to 2023
afdust_adj	0	0	0%
ag	0	0	0%
agfire	1,030,817	1,030,817	0%
cmv_c1c2	58,543	57,696	-1%
cmv_c3	11,955	18,569	55%
nonpt	1,645,989	1,682,696	2%
np_oilgas	635,942	690,025	9%
nonroad	13,951,020	12,627,798	-9%
onroad	25,981,557	11,300,137	-57%
ptfire	20,562,697	20,562,697	0%
ptegu	792,414	598,510	-24%
ptnonipm	2,297,549	2,271,136	-1%
pt_oilgas	235,162	231,798	-1%
rail	122,703	145,627	19%
rwc	2,517,844	2,368,934	-6%
Con U.S. Total	**69,844,194**	**53,586,440**	**-23%**
Offshore to EEZ	176,338	205,146	16%
Non-US SECA C3	16,191	27,845	72%
Canada othafdust	0	0	0%
Canada othar	2,038,390	2,192,418	8%
Canada othon	1,507,754	877,268	-42%
Canada othpt	512,629	636,056	24%
Canada ptfire_mxca	798,710	798,710	0%
Mexico othar	186,575	217,518	17%
Mexico othon	1,476,625	1,543,506	5%
Mexico othpt	153,387	199,007	30%
Mexico ptfire_mxca	736,810	736,810	0%
Non-US Total	**7,603,409**	**7,434,284**	**-2%**

Table 5-4. National by-sector NH_3 emissions (tons/yr) summaries and percent change

Sector	2011 NH_3	2023 NH_3	% change 2011 to 2023
afdust_adj	0	0	0%
ag	3,515,198	3,602,039	2%
agfire	3,321	3,321	0%
cmv_c1c2	167	170	2%
cmv_c3	65	65	0%
nonpt	94,242	94,695	0%
np_oilgas	0	0	0%
nonroad	2,627	3,228	23%
onroad	120,859	82,106	-32%
ptfire	329,330	329,330	0%
ptegu	25,066	29,691	18%
ptnonipm	66,048	64,691	-2%
pt_oilgas	5,947	5,917	-1%
rail	347	376	8%
rwc	19,693	18,499	-6%
Con U.S. Total	**4,182,911**	**4,234,128**	**1%**
Offshore to EEZ	188	188	0%
Non-US SECA C3	0	0	0%
Canada othafdust	0	0	0%
Canada othar	338,056	338,711	0%
Canada othon	6,326	5,098	-19%
Canada othpt	11,390	15,412	35%
Canada ptfire_mxca	13,037	13,037	0%
Mexico othar	168,840	167,660	-1%
Mexico othon	2,154	2,853	32%
Mexico othpt	3,945	5,669	44%
Mexico ptfire_mxca	13,583	13,583	0%
Non-US Total	**557,519**	**562,210**	**1%**

Table 5-5. National by-sector NO_x emissions (tons/yr) summaries and percent change

Sector	2011 NO_x	2023 NO_x	% change 2011 to 2023
afdust_adj	0	0	0%
ag	0	0	0%
agfire	46,035	46,035	0%
cmv_c1c2	288,726	175,059	-39%
cmv_c3	125,374	105,567	-16%
nonpt	720,454	733,016	2%
np_oilgas	667,068	670,895	1%
nonroad	1,630,301	856,831	-47%
onroad	5,708,150	1,786,856	-69%
ptfire	333,398	333,398	0%
ptegu	2,096,058	1,051,725	-50%
ptnonipm	1,212,616	1,156,792	-5%
pt_oilgas	509,856	424,595	-17%
rail	791,381	563,382	-29%
rwc	34,436	34,918	1%
Con U.S. Total	**14,163,853**	**7,939,069**	**-44%**
Offshore to EEZ	904,453	716,768	-21%
Non-US SECA C3	191,001	266,129	39%
Canada othafdust	0	0	0%
Canada othar	376,758	238,830	-37%
Canada othon	332,349	141,282	-57%
Canada othpt	231,609	221,980	-4%
Canada ptfire_mxca	14,048	14,048	0%
Mexico othar	183,383	212,147	16%
Mexico othon	363,342	376,485	4%
Mexico othpt	333,368	376,422	13%
Mexico ptfire_mxca	31,403	31,403	0%
Non-US Total	**2,961,713**	**2,595,494**	**-12%**

Table 5-6. National by-sector $PM_{2.5}$ emissions (tons/yr) summaries and percent change

Sector	**2011 $PM_{2.5}$**	**2023 $PM_{2.5}$**	**% change 2011 to 2023**
afdust_adj	923,590	1,009,616	9%
ag	0	0	0%
agfire	101,379	101,379	0%
cmv_c1c2	9,294	5,155	-45%
cmv_c3	8,829	1,884	-79%
nonpt	404,258	427,719	6%
np_oilgas	16,333	21,786	33%
nonroad	154,657	78,858	-49%
onroad	188,925	79,527	-58%
ptfire	1,844,263	1,844,263	0%
ptegu	208,122	138,932	-33%
ptnonipm	320,816	320,641	0%
pt_oilgas	13,935	14,847	7%
rail	23,963	13,165	-45%
rwc	381,252	362,651	-5%
Con U.S. Total	**4,599,616**	**4,420,423**	**-4%**
Offshore to EEZ	24,692	9,125	-63%
Non-US SECA C3	14,930	9,371	-37%
Canada othafdust	242,374	270,071	11%
Canada othar	157,205	151,849	-3%
Canada othon	5,014	5,025	0%
Canada othpt	25,784	31,196	21%
Canada ptfire_mxca	73,401	73,401	0%
Mexico othar	42,623	46,311	9%
Mexico othon	3,254	4,586	41%
Mexico othpt	45,963	54,940	20%
Mexico ptfire_mxca	87,025	87,025	0%
Non-US Total	**722,265**	**742,899**	**3%**

Table 5-7. National by-sector PM_{10} emissions (tons/yr) summaries and percent change

Sector	2011 PM_{10}	2023 PM_{10}	% change 2011 to 2023
afdust_adj	6,732,941	7,498,365	11%
ag	0	0	0%
agfire	152,837	152,837	0%
cmv_c1c2	9,712	5,387	-45%
cmv_c3	9,946	2,126	-79%
nonpt	491,825	509,892	4%
np_oilgas	17,784	24,780	39%
nonroad	162,417	84,153	-48%
onroad	326,900	232,752	-29%
ptfire	2,171,987	2,171,987	0%
ptegu	283,066	173,057	-39%
ptnonipm	477,328	473,720	-1%
pt_oilgas	14,585	15,508	6%
rail	25,898	14,236	-45%
rwc	381,476	362,897	-5%
Con U.S. Total	**11,258,702**	**11,721,698**	**4%**
Offshore to EEZ	26,401	9,630	-64%
Non-US SECA C3	16,228	10,232	-37%
Canada othafdust	1,192,039	1,353,416	14%
Canada othar	288,021	284,898	-1%
Canada othon	15,107	5,520	-63%
Canada othpt	51,137	57,514	12%
Canada ptfire_mxca	87,398	87,398	0%
Mexico othar	90,691	95,486	5%
Mexico othon	8,788	9,581	9%
Mexico othpt	59,325	71,542	21%
Mexico ptfire_mxca	104,125	104,125	0%
Non-US Total	**1,939,261**	**2,089,342**	**8%**

Table 5-8. National by-sector SO_2 emissions (tons/yr) summaries and percent change

Sector	**2011 SO_2**	**2023 SO_2**	**% change 2011 to 2023**
afdust_adj	0	0	0%
ag	0	0	0%
agfire	17,755	17,755	0%
cmv_c1c2	6,217	1,987	-68%
cmv_c3	84,992	4,824	-94%
nonpt	276,332	96,043	-65%
np_oilgas	17,232	49,707	188%
nonroad	4,031	2,380	-41%
onroad	28,195	12,114	-57%
ptfire	165,773	165,773	0%
ptegu	4,670,713	1,335,974	-71%
ptnonipm	1,049,374	731,219	-30%
pt_oilgas	66,577	64,990	-2%
rail	7,936	340	-96%
rwc	8,954	7,908	-12%
Con U.S. Total	**6,404,080**	**2,491,013**	**-61%**
Offshore to EEZ	139,270	11,615	-92%
Non-US SECA C3	120,316	69,507	-42%
Canada othafdust	0	0	0%
Canada othar	33,464	22,783	-32%
Canada othon	1,270	549	-57%
Canada othpt	522,537	409,282	-22%
Canada ptfire_mxca	6,481	6,481	0%
Mexico othar	10,184	12,159	19%
Mexico othon	4,432	6,370	44%
Mexico othpt	471,847	361,230	-23%
Mexico ptfire_mxca	6,394	6,394	0%
Non-US Total	**1,316,195**	**906,371**	**-31%**

Table 5-9. National by-sector VOC emissions (tons/yr) summaries and percent change

Sector	2011 VOC	2023 VOC	% change 2011 to 2023
afdust_adj	0	0	0%
ag	0	0	0%
agfire	80,540	80,540	0%
cmv_c1c2	7,696	5,241	-32%
cmv_c3	4,888	7,639	56%
nonpt	3,671,322	3,452,177	-6%
np_oilgas	2,482,590	2,966,396	19%
nonroad	2,024,419	1,177,147	-42%
onroad	2,713,181	987,796	-64%
ptfire	4,688,094	4,688,094	0%
ptegu	38,060	32,702	-14%
ptnonipm	800,815	782,504	-2%
pt_oilgas	164,098	177,353	8%
rail	40,851	21,384	-48%
rwc	442,541	415,748	-6%
Con U.S. Total	**17,159,096**	**14,794,722**	**-14%**
Offshore to EEZ	81,713	92,462	13%
Non-US SECA C3	6,878	11,821	72%
Canada othafdust	0	0	0%
Canada othar	776,733	800,300	3%
Canada othon	138,319	47,883	-65%
Canada othpt	166,284	186,100	12%
Canada ptfire_mxca	194,844	194,844	0%
Mexico othar	420,637	505,017	20%
Mexico othon	136,891	143,725	5%
Mexico othpt	57,090	80,922	42%
Mexico ptfire_mxca	172,196	172,196	0%
Non-US Total	**2,151,585**	**2,235,269**	**4%**

Table 5-10. Canadian province emissions changes from 2011 to 2023 for othon sector

2023 othon emissions (tons)	2011	2023	% diff (2023-2011)	2011	2023	% diff (2023-2011)	2011	2023	% diff (2023-2011)
Province	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Newfoundland	38,454	18,791	-51.1%	6,054	2,611	-56.9%	2,439	818	-66.4%
Prince Edward Island	12,516	6,398	-48.9%	2,985	1,100	-63.1%	980	300	-69.4%
Nova Scotia	66,500	30,624	-53.9%	10,626	4,183	-60.6%	4,560	1,385	-69.6%
New Brunswick	62,881	30,018	-52.3%	12,978	4,945	-61.9%	4,956	1,576	-68.2%
Quebec	450,802	238,728	-47.0%	94,288	33,176	-64.8%	33,137	10,911	-67.1%
Ontario	583,811	387,770	-33.6%	133,818	49,835	-62.8%	58,001	19,480	-66.4%
Manitoba	147,307	72,096	-51.1%	28,630	15,482	-45.9%	16,257	5,558	-65.8%
Saskatchewan	160,734	88,473	-45.0%	39,296	26,347	-33.0%	16,126	6,618	-59.0%
Alberta	428,529	249,051	-41.9%	108,703	69,301	-36.2%	38,108	15,453	-59.5%
British Columbia	296,378	158,262	-46.6%	64,498	30,926	-52.1%	29,932	10,786	-64.0%
Yukon	5,977	1,993	-66.7%	1,969	1,004	-49.0%	585	161	-72.4%
N W Territories	5,301	2,015	-62.0%	1,215	632	-48.0%	454	142	-68.7%
Nunavut	0	0	0.0%	0	0	0.0%	0	0	0.0%
Canada Total	2,259,190	1,284,220	-43.2%	505,059	239,542	-52.6%	205,535	73,190	-64.4%

Table 5-11. Canadian province emissions changes from 2011 to 2023 for othar sector

2023 othar emissions (tons)	2011	2023	% diff (2023-2011)	2011	2023	% diff (2023-2011)	2011	2023	% diff (2023-2011)
Province	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Newfoundland	240,084	266,592	11.0%	44,914	31,834	-29.1%	66,538	73,243	10.1%
Prince Edward Island	25,798	26,965	4.5%	3,179	1,661	-47.8%	8,447	8,584	1.6%
Nova Scotia	116,388	104,911	-9.9%	46,345	20,535	-55.7%	37,795	34,034	-10.0%
New Brunswick	78,228	84,324	7.8%	12,980	8,326	-35.9%	28,181	30,887	9.6%
Quebec	970,074	995,472	2.6%	124,163	72,342	-41.7%	278,853	280,783	0.7%
Ontario	977,428	1,043,706	6.8%	138,510	95,720	-30.9%	326,896	333,517	2.0%
Manitoba	100,965	121,472	20.3%	35,123	19,465	-44.6%	63,740	69,277	8.7%
Saskatchewan	120,537	133,515	10.8%	73,713	40,146	-45.5%	97,252	98,004	0.8%
Alberta	312,576	377,812	20.9%	150,466	106,892	-29.0%	219,727	241,602	10.0%
British Columbia	282,114	314,793	11.6%	133,298	77,738	-41.7%	104,627	113,422	8.4%
Yukon	7,418	7,822	5.4%	419	6,441	1435.6%	2,439	2,566	5.2%
N W Territories	4,094	3,239	-20.9%	2,536	1,864	-26.5%	1,536	1,187	-22.7%
Nunavut	30,279	41,032	35.5%	3,228	12,542	288.5%	7,776	11,101	42.8%
Canada Total	3,265,982	3,521,654	7.8%	768,873	495,504	-35.6%	1,243,806	1,298,207	4.4%

Table 5-12. Canadian province emissions changes from 2011 to 2023 for othpt sector

2023 othpt emissions (tons)	**2011**	**2023**	**% diff (2023-2011)**	**2011**	**2023**	**% diff (2023-2011)**	**2011**	**2023**	**% diff (2023-2011)**
Province	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Newfoundland	9,951	11,245	13.0%	15,449	17,288	11.9%	4,707	4,984	5.9%
Prince Edward Island	167	153	-8.4%	269	234	-13.0%	210	236	12.7%
Nova Scotia	16,033	3,616	-77.4%	23,948	17,174	-28.3%	5,853	4,841	-17.3%
New Brunswick	20,861	24,210	16.1%	15,790	17,138	8.5%	6,465	7,275	12.5%
Quebec	470,224	641,119	36.3%	39,911	42,254	5.9%	37,770	39,339	4.2%
Ontario	92,784	103,009	11.0%	76,441	77,106	0.9%	64,127	64,552	0.7%
Manitoba	4,777	5,583	16.9%	3,590	4,250	18.4%	23,880	20,134	-15.7%
Saskatchewan	47,251	47,839	1.2%	69,971	57,526	-17.8%	188,075	223,364	18.8%
Alberta	556,850	574,346	3.1%	489,584	421,837	-13.8%	556,009	554,800	-0.2%
British Columbia	181,571	280,949	54.7%	86,375	140,438	62.6%	74,301	104,369	40.5%
Yukon	288	216	-25.1%	18	27	50.7%	24	32	33.2%
N W Territories	4,217	4,847	14.9%	9,497	15,040	58.4%	2,036	2,155	5.9%
Nunavut	843	686	-18.6%	3,154	1,110	-64.8%	49	37	-23.3%
Canada Total	1,405,817	1,697,818	20.8%	833,998	811,424	-2.7%	963,504	1,026,119	6.5%

Table 5-13. Mexican state emissions changes from 2011 to 2023 for othon sector

2023 othon emissions (tons)	**2011el**	**2023el**	**% diff (2023el-2011el)**	**2011el**	**2023el**	**% diff (2023el-2011el)**	**2011el**	**2023el**	**% diff (2023el-2011el)**
State	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Aguascalientes	74,458	72,499	-2.6%	18,716	19,700	5.3%	7,126	7,314	2.6%
Baja Calif Norte	292,747	316,731	8.2%	74,570	77,577	4.0%	25,233	26,025	3.1%
Baja Calif Sur	83,274	91,452	9.8%	19,961	20,750	4.0%	6,999	7,340	4.9%
Campeche	52,849	58,506	10.7%	9,367	9,834	5.0%	3,948	4,122	4.4%
Coahuila	170,357	165,632	-2.8%	38,217	40,294	5.4%	15,532	16,135	3.9%
Colima	59,533	65,737	10.4%	11,485	12,026	4.7%	4,735	5,004	5.7%
Chiapas	114,015	125,700	10.2%	23,295	24,325	4.4%	9,109	9,519	4.5%
Chihuahua	280,049	271,634	-3.0%	76,676	80,295	4.7%	26,460	27,193	2.8%
Distrito Federal	602,306	602,050	0.0%	143,350	138,120	-3.6%	60,134	60,474	0.6%
Durango	98,318	107,195	9.0%	24,238	25,168	3.8%	8,817	9,370	6.3%
Guanajuato	230,777	224,860	-2.6%	57,800	60,848	5.3%	22,563	23,431	3.8%
Guerrero	156,199	172,474	10.4%	28,815	30,232	4.9%	12,770	13,669	7.0%
Hidalgo	131,136	127,736	-2.6%	34,009	35,730	5.1%	12,794	13,110	2.5%
Jalisco	456,462	433,740	-5.0%	122,360	125,191	2.3%	45,893	47,241	2.9%
Mexico	413,998	448,551	8.3%	102,556	103,470	0.9%	38,111	38,793	1.8%
Michoacan	301,589	330,111	9.5%	68,641	71,574	4.3%	27,435	29,395	7.1%
Morelos	83,388	81,392	-2.4%	19,926	20,997	5.4%	7,929	8,274	4.3%
Nayarit	71,260	78,690	10.4%	13,702	14,352	4.7%	5,947	6,409	7.8%
Nuevo Leon	340,264	353,709	4.0%	86,518	86,734	0.3%	34,033	35,793	5.2%
Oaxaca	98,480	95,690	-2.8%	26,792	27,781	3.7%	8,496	8,625	1.5%
Puebla	196,606	212,743	8.2%	49,244	51,425	4.4%	18,745	19,950	6.4%
Queretaro	71,514	69,650	-2.6%	20,361	21,327	4.7%	6,963	7,164	2.9%
Quintana Roo	67,166	65,537	-2.4%	13,672	14,466	5.8%	5,594	5,739	2.6%
San Luis Potosi	144,504	140,708	-2.6%	32,362	34,138	5.5%	13,518	14,187	4.9%
Sinaloa	203,180	223,769	10.1%	46,984	48,875	4.0%	17,555	18,869	7.5%
Sonora	195,052	214,002	9.7%	46,289	48,130	4.0%	17,094	18,303	7.1%
Tabasco	93,227	103,029	10.5%	17,304	18,148	4.9%	7,343	7,754	5.6%
Tamaulipas	296,180	325,932	10.0%	58,506	61,170	4.6%	24,360	25,872	6.2%
Tlaxcala	33,247	32,217	-3.1%	8,901	9,355	5.1%	3,266	3,321	1.7%
Veracruz	265,631	259,302	-2.4%	68,186	71,617	5.0%	24,046	24,651	2.5%
Yucatan	97,722	95,382	-2.4%	20,606	21,783	5.7%	8,431	8,745	3.7%
Zacatecas	112,450	122,582	9.0%	28,420	29,527	3.9%	10,411	11,130	6.9%
Mexico Total	5,887,937	6,088,942	3.4%	1,411,830	1,454,958	3.1%	541,390	562,919	4.0%

Table 5-14. Mexican state emissions changes from 2011 to 2023 for othar sector

2023 othar emissions (tons)	**2011el**	**2023el**	**% diff (2023el-2011el)**	**2011el**	**2023el**	**% diff (2023el-2011el)**	**2011el**	**2023el**	**% diff (2023el-2011el)**
State	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Aguascalientes	4,018	4,901	22.0%	6,605	7,492	13.4%	19,358	23,699	22.4%
Baja Calif Norte	13,589	19,079	40.4%	21,841	28,254	29.4%	61,514	77,009	25.2%
Baja Calif Sur	3,110	4,372	40.6%	4,996	6,085	21.8%	10,889	14,748	35.4%
Campeche	51,137	55,561	8.7%	35,074	34,844	-0.7%	35,129	41,592	18.4%
Coahuila	12,444	14,769	18.7%	15,089	19,367	28.4%	48,687	58,739	20.6%
Colima	8,562	10,303	20.3%	3,883	4,601	18.5%	16,571	20,176	21.8%
Chiapas	305,524	354,916	16.2%	22,097	23,492	6.3%	312,206	365,483	17.1%
Chihuahua	61,301	67,860	10.7%	55,606	59,045	6.2%	99,006	116,057	17.2%
Distrito Federal	10,780	14,230	32.0%	7,966	10,765	35.1%	108,040	112,654	4.3%
Durango	39,499	43,328	9.7%	27,428	28,670	4.5%	51,830	59,027	13.9%
Guanajuato	71,662	83,363	16.3%	41,641	49,568	19.0%	122,993	141,500	15.0%
Guerrero	156,577	167,856	7.2%	5,770	6,172	7.0%	176,647	192,150	8.8%
Hidalgo	98,080	110,966	13.1%	17,781	21,582	21.4%	113,582	128,929	13.5%
Jalisco	61,762	70,602	14.3%	47,329	50,076	5.8%	147,659	174,141	17.9%
Mexico	178,322	219,642	23.2%	32,009	37,849	18.2%	344,893	416,931	20.9%
Michoacan	115,037	132,429	15.1%	21,496	37,382	73.9%	152,964	171,488	12.1%
Morelos	26,857	27,190	1.2%	13,692	5,457	-60.1%	45,963	52,672	14.6%
Nayarit	23,142	26,534	14.7%	13,483	13,091	-2.9%	30,199	36,612	21.2%
Nuevo Leon	31,440	38,770	23.3%	24,518	30,517	24.5%	88,474	108,061	22.1%
Oaxaca	238,829	255,390	6.9%	13,735	14,059	2.4%	250,320	270,763	8.2%
Puebla	202,340	227,306	12.3%	17,744	21,075	18.8%	250,507	283,412	13.1%
Queretaro	26,941	34,278	27.2%	8,463	12,791	51.1%	50,165	61,365	22.3%
Quintana Roo	26,335	35,351	34.2%	5,137	5,773	12.4%	38,633	53,296	38.0%
San Luis Potosi	88,201	98,880	12.1%	22,207	27,521	23.9%	106,283	118,702	11.7%
Sinaloa	54,362	59,869	10.1%	35,373	38,123	7.8%	76,165	85,204	11.9%
Sonora	26,007	30,706	18.1%	23,917	27,984	17.0%	60,018	72,372	20.6%
Tabasco	91,388	102,556	12.2%	14,024	16,009	14.1%	103,490	117,803	13.8%
Tamaulipas	44,743	51,876	15.9%	46,959	54,576	16.2%	70,902	83,656	18.0%
Tlaxcala	21,451	25,104	17.0%	6,672	7,438	11.5%	32,549	38,656	18.8%
Veracruz	357,503	389,550	9.0%	48,159	50,987	5.9%	390,957	432,607	10.7%
Yucatan	97,808	113,125	15.7%	7,176	7,935	10.6%	111,556	131,043	17.5%
Zacatecas	30,865	32,736	6.1%	38,745	40,253	3.9%	36,798	40,838	11.0%
Mexico Total	2,579,614	2,923,397	13.3%	706,612	798,834	13.1%	3,564,949	4,101,385	15.0%

Table 5-15. Mexican state emissions changes from 2011 to 2023 for othpt sector

2023 othpt emissions (tons)	**2011el**	**2023el**	**% diff (2023el-2011el)**	**2011el**	**2023el**	**% diff (2023el-2011el)**	**2011el**	**2023el**	**% diff (2023el-2011el)**
State	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Aguascalientes	275	391	42.3%	987	1,407	42.6%	2,151	3,069	42.7%
Baja Calif Norte	8,083	17,500	116.5%	14,498	32,455	123.9%	13,603	19,505	43.4%
Baja Calif Sur	644	173	-73.1%	8,899	2,582	-71.0%	610	771	26.4%
Campeche	9,342	11,361	21.6%	35,616	41,077	15.3%	3,637	4,324	18.9%
Coahuila	31,659	35,549	12.3%	217,689	218,533	0.4%	7,328	10,306	40.6%
Colima	1,496	1,052	-29.7%	15,921	7,294	-54.2%	1,514	2,152	42.1%
Chiapas	2,861	3,919	37.0%	5,503	7,500	36.3%	3,926	5,439	38.5%
Chihuahua	11,318	15,659	38.4%	11,989	13,663	14.0%	5,540	7,803	40.8%
Distrito Federal	887	1,321	49.0%	2,582	3,853	49.2%	25,747	36,748	42.7%
Durango	3,552	4,737	33.4%	6,988	7,371	5.5%	3,727	5,261	41.1%
Guanajuato	78,844	95,712	21.4%	9,566	12,567	31.4%	11,245	14,846	32.0%
Guerrero	3,200	3,184	-0.5%	14,706	14,270	-3.0%	785	952	21.2%
Hidalgo	123,941	218,498	76.3%	35,641	50,270	41.0%	8,325	14,004	68.2%
Jalisco	3,766	5,367	42.5%	7,403	10,547	42.5%	18,313	26,129	42.7%
Mexico	7,294	14,501	98.8%	17,656	35,567	101.4%	56,433	81,136	43.8%
Michoacan	3,341	4,753	42.3%	4,966	6,938	39.7%	6,306	8,997	42.7%
Morelos	1,553	2,216	42.7%	4,249	6,064	42.7%	3,381	4,825	42.7%
Nayarit	553	789	42.8%	375	538	43.2%	1,673	2,387	42.7%
Nuevo Leon	86,971	107,975	24.1%	41,887	57,573	37.4%	15,730	22,180	41.0%
Oaxaca	113,001	135,442	19.9%	10,928	13,944	27.6%	8,267	10,729	29.8%
Puebla	2,994	4,748	58.6%	7,360	11,104	50.9%	4,317	6,168	42.9%
Queretaro	3,184	6,613	107.7%	9,793	22,762	132.4%	7,013	10,332	47.3%
Quintana Roo	410	550	34.1%	616	388	-37.0%	1,016	1,441	41.8%
San Luis Potosi	6,764	14,529	114.8%	22,263	33,743	51.6%	7,563	11,590	53.2%
Sinaloa	1,315	1,098	-16.5%	10,982	2,049	-81.3%	3,641	5,076	39.4%
Sonora	4,299	8,350	94.2%	14,581	18,526	27.1%	4,786	7,018	46.6%
Tabasco	7,682	10,102	31.5%	23,255	29,986	28.9%	6,767	8,468	25.1%
Tamaulipas	71,893	89,752	24.8%	34,020	42,968	26.3%	34,256	46,543	35.9%
Tlaxcala	286	435	52.1%	962	1,531	59.1%	1,425	2,033	42.7%
Veracruz	88,864	108,452	22.0%	48,607	56,892	17.0%	30,199	40,973	35.7%
Yucatan	3,210	3,679	14.6%	11,020	11,529	4.6%	4,454	6,206	39.3%
Zacatecas	3	4	42.0%	11	15	42.4%	226	322	42.7%
Mexico Total	683,482	928,414	35.8%	651,521	775,506	19.0%	303,905	427,730	40.7%

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