Technical Support Document (TSD): Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2023

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Technical Support Document (TSD): Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2023

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Office of Air Quality Planning and Standards
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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 the Final Cross-state Air Pollutant Update Rule that addresses 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). 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 2015 Ozone NAAQS. Much of the 2011 data from the 2011v6.3 platform was unchanged for this updated platform, although a different future year was used for the two analyses. For more information on the 2011v6.3 platform, see the data files and the technical support document (TSD) Preparation of Emission Inventories for the version 6.3, 2011 Emissions Modeling Platform, available from EPA's Air Emissions Modeling website for the version 6.3 platform (EPA, 2016).

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, version 6.32. However, emissions are first processed into a format compatible with for the Community Multiscale Air Quality (CMAQ) model, version 5.0.2, and those emissions are converted to CAMx-ready format.

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., 2011el_cb6v2_v6), and the 2023 base case (i.e., 2023e1_cb6v2_v6). Most of the 2011 emissions in this update to the 2011v6.3 platform are the same as those used in the 2011v6.3 platform, thus this platform has not been given a new version number. 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 "l" represents that this was the twelfth set of emissions modeled for a 2011-based modeling platform (i.e., the first case for the 2011 platform was 2011ea, the second was 2011eb, and so on). Table 1-1 provides more information on these emissions cases. 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.

For regulatory applications, 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, "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM 2.5, and Regional Haze".

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	2011el_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 added.
2023 base case	2023el_cb6v2_v6	2023 "base case" scenario, representing the best estimate for 2023 that incorporates estimates of the impact of current "on-the-books" regulations.

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 2023el_cb6v2_v6 case called 2023el_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://newftp.epa.gov/air/emismod/2011/v3platform/.

The EPA has adopted 2023 as the analytic year for this effort because it is the year by which moderate areas need to be in attainment for the 2015 Ozone NAAQS. 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).

The primary emissions modeling tool used to create the air quality model-ready emissions was the SMOKE modeling system. 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.

The gridded meteorological model used for the emissions modeling was developed using the Weather Research and Forecasting Model (WRF) 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 was run for 2011 over a domain covering the continental U.S. at a 12km resolution with 35 vertical layers. The WRF data 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) 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. Table 2-1 presents the sectors in this update to the 2011 platform that differ from the original 2011v6.3 platform. 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.

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**
Category 1, 2 and 3 CMV: ***cmv***	Category 1 (C1), category 2 (C2) and category 3 (C3) commercial marine vessel (CMV) emissions sources from the 2011NEIv2 nonpoint inventory. County and annual resolution; see othpt sector for all non-U.S. C3 emissions. *Includes updated cmv emissions for California.*
Onroad: ***onroad***	2011 onroad mobile source gasoline and diesel vehicles from parking lots and moving vehicles. Includes the following modes: 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 from the original 2011v6.3 platform*. 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). *Ethanol-85 usage in 2011 VMT was reduced to reflect actual percentage of E-85 used*.
Non-US. fires: ***ptfire_mxca***	*New Sector added:* 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.
Other point sources not from the 2011 NEI: ***othpt***	Point sources from Canada's 2010 inventory and Mexico's 2008 inventory *projected to 2011*, annual resolution. Also includes all non-U.S. C3 CMV and U.S. offshore oil production.
Other non-NEI nonpoint and nonroad: ***othar***	Monthly year 2010 Canada (province resolution) and Mexico's 2008 nonpoint and nonroad mobile inventories *projected to 2011* (municipio resolution).
Other non-NEI onroad sources: ***othon***	Monthly year 2010 Canada (province / annual resolution) onroad mobile inventories and *MOVES-Mexico emissions for 2011* (municipio / monthly resolution).

The emissions for the remaining sectors are unchanged from those in the 2011ek case and documentation for these sectors can be found in the 2011v6.3 TSD:

- *ptegu* – electric generating units
- *pt_oilgas* – point oil and gas sources
- *ptnonipm* – remaining non-EGU point sources

- *ag* – agricultural ammonia emissions
- *agfire* – agricultural fire emissions
- *afdust* – area fugitive dust emissions
- *othafdust* – area fugitive dust emissions for Canada
- *beis* – biogenic emissions
- *rail* – locomotive emissions
- *nonpt* – remaining nonpoint source emissions
- *np_oilgas* – nonpoint sources from oil and gas-related processes
- *rwc* – residential wood combustion emissions
- *nonroad* – emissions from nonroad mobile source equipment

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. A number of reports (i.e., summaries) are available with the data files for the updated 2011v6.3 platform. 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 *2011el_vs_2011ek_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 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 and hourly meteorological data. For more information on the preparation of onroad mobile source emissions with SMOKE-MOVES, see the 2011v6.3 platform TSD.

The primary change to the onroad mobile source sector made for this update to the 2011v6.3 platform 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 2-2 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 2-2. 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 this update to the 2011v6.3 platform. The new California onroad inventory includes an updated vehicle type and road type distribution, so that they are estimated in a consistent way with the state-provided 2023 emissions. The new 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.

2.2 Category 1, Category 2, Category 3 Commercial Marine Vessels (cmv)

The cmv sector contains Category 1, 2 and 3 CMV emissions. All emissions in this sector are annual and at the county-SCC resolution. The Category 3 (C3) CMV sources in the cmv sector of the 2011v6.3 platform run on residual oil and use the SCCs 2280003100 and 2280003200 for port and underway emissions, respectively, and are consistent with the 2011NEIv2. Emissions for this sector use state-submitted values and EPA-developed emissions in areas where states did not submit. The change in this update to the 2011v6.3 platforms is to incorporate updated CMV emissions in California so that they are estimated in a consistent way with the state-provided 2023 emissions. The CMV CAP emissions for California in the original and updated cases are shown in Table 2-3.

Table 2-3. California CMV CAP emissions in the 2011v6.3 and updated 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

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

The emissions from Canada, Mexico, and non-U.S. offshore Category 3 Commercial Marine Vessels (C3 CMV) and 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 in the U.S. state-county geographic Federal Information Processing Standards (FIPS), and the remaining characters provide the SMOKE source types: "pt" for point; "ar" for "area and nonroad mobile;" and "on" for onroad mobile. Only the emissions for Mexico have changed in this update to the platform. The changes in emissions for the entire country of Mexico for each sector are shown in Table 2-4.

Table 2-4. Mexico CAP emissions in the 2011v6.3 and updated platforms (tons)

	CO	NH3	NOX	PM10	PM2_5	SO2	VOC

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

2.3.1 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, point sources for Canada and Mexico along with the ECA-IMO-based C3 CMV emissions outside of state waters. Point sources in Mexico were compiled based on the Inventario Nacional de Emisiones de Mexico, 2008 (ERG, 2014a) and in this updated case, they were projected to the year 2011 by 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 remaining sources in the sector were unchanged in this update. The point source offshore oil and gas drilling platforms from the 2011NEIv2 were used. For Canadian point sources, 2010 emissions provided by Environment Canada were used. Note that VOC was not provided for Canadian point sources, but any VOC emissions were speciated into CB05 species. Temporal profiles and speciated emissions were also provided.

The C3 CMV emissions in this sector include those assigned to U.S. federal waters, Canada, those assigned to 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), along with any other offshore emissions. These emissions are developed in the same way as the EPA-dataset for the cmv sector. Emissions in U.S. waters are aggregated into large regions and included in the 2011NEIv2 using special FIPS codes. Because these emissions are treated as point sources, shipping lane routes can be preserved and they may be allocated to air quality model layers higher than layer 1.

2.3.2 Area and Nonroad Mobile Sources from Canada and Mexico (othar)

The othar sector includes nonpoint and nonroad mobile source emissions in Canada and Mexico. The Canadian sources are unchanged from the 2011v6.3 platform and are based on month-specific year-2010 emissions provided by Environment Canada, including C3 CMV emissions.

The change in this sector in this update to the platform was in the Mexico emissions. 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, projected to the year 2014 (ERG, 2016), and then linearly interpolated back to 2011. Also, 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.

2.3.3 Onroad Mobile Sources from Canada and Mexico (othon)

The othon sector includes onroad mobile source emissions in Canada and Mexico. The Canadian sources are unchanged from the 2011v6.3 platform and are based on month-specific year-2010 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.

The update to this sector was for the onroad mobile sources in Mexico. These emissions were based on a run of MOVES-Mexico for 2011 and is described in Development of Mexico Emission Inventories for the 2014 Modeling Platform (ERG, 2016). This document includes a comparison of emissions from MOVES-Mexico with other recent inventories of onroad mobile sources in Mexico. Please see the document for more information. The following information about MOVES-Mexico and how the 2011 inventory was developed is a collection of excerpts from that document:

> "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."

2.4 Non-U.S. Fires (ptfire_mxca)

In this 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 2-5. 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 fire inventory for Canada was obtained from Environment Canada. This point source fire inventory was generated using the Canadian Wildland Fire Information System (CWFIS). 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 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 and was converted to SMOKE FF10 format for use in this modeling effort.

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 the 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 2011v6.3 TSD.

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 0. 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 vertical layers of the sources are not included.

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 this platform update are 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 biogenics 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.

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	Surrogates	Yes	annual	
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	in-line
pt_oilgas	Point	Yes	annual	in-line
ptegu	Point	Yes	daily & hourly	in-line

Platform sector	Spatial	Speciation	Inventory resolution	Plume rise
ptfire	Point	Yes	daily	in-line
ptfire_mxca	Point	Yes	daily	in-line
ptnonipm	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 3-dimensional files). This occurs when stacks with different stack parameters or latitudes/longitudes are grouped, thereby changing the parameters of one or more sources. The most straightforward way to get the same results between in-line and offline is to avoid the use of grouping.

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.

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.

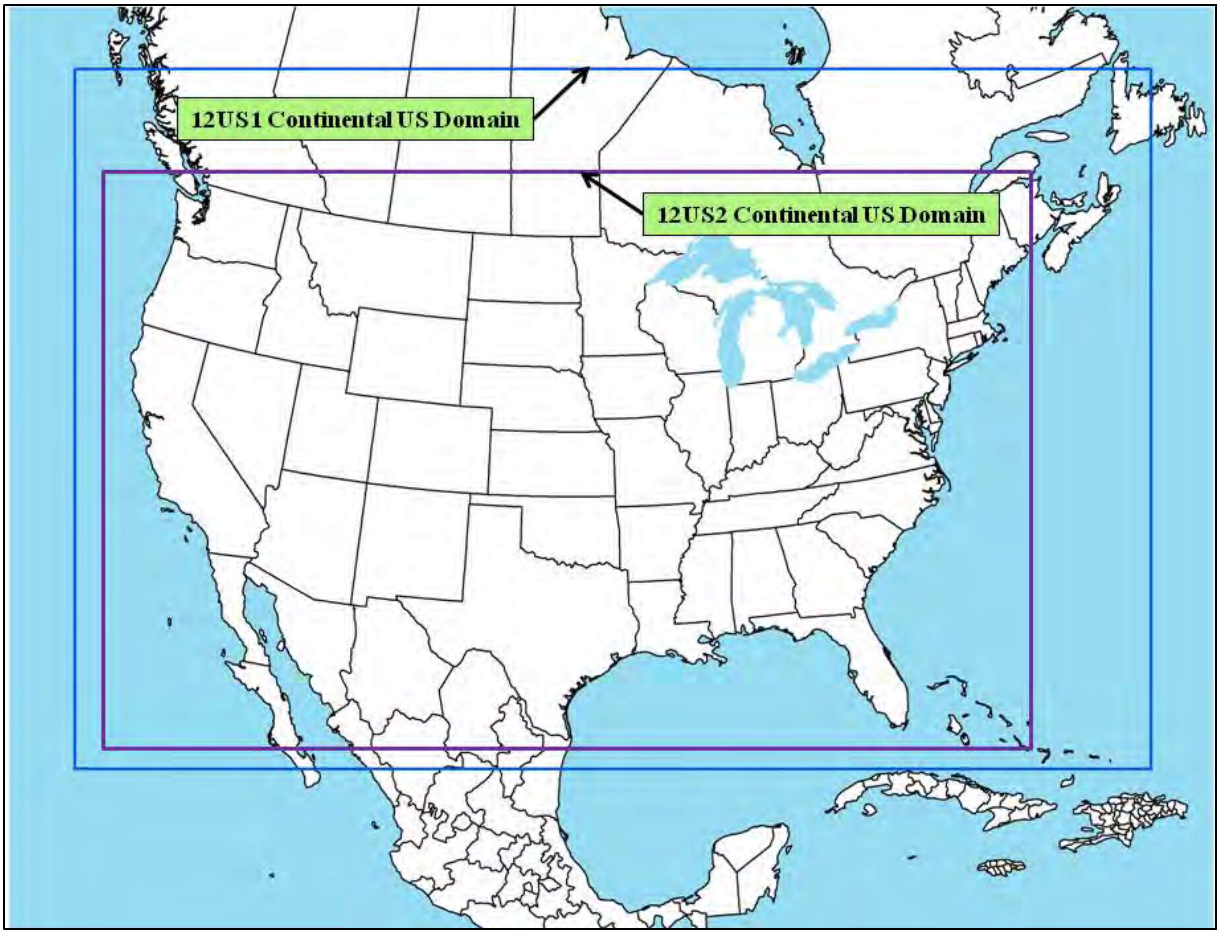
5) The netCDF fire files are converted to a CAMx "PTSOURCE" type file where each grid cell centroid represents one stack using the *cmaq2uam* program. Note that each virtual stack has default stack parameters of 1 m height, 1 m diameter, 273 K temperature, and 1 m/s velocity. Also, an individual virtual 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 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, 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 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 $PM_{2.5}$.

Only minor changes were made to the speciation cross reference in this update to the 2011v6.3 platform. 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.

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://newftp.epa.gov/air/emismod/2011/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 3-3 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 3-3. Temporal settings used for the platform sectors in SMOKE

Platform sector short name	Inventory resolutions	Monthly profiles used?	Daily temporal approach	Merge processing approach	Process Holidays as separate days
afdust_adj	Annual	Yes	week	all	Yes
ag	Annual	Yes	all	all	Yes
agfire	Monthly		week	week	Yes
beis	Hourly		n/a	all	Yes
cmv	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	yes	mwdss	mwdss	
pt_oilgas	Annual	yes	mwdss	mwdss	Yes
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.

The only change to the temporal allocation process in this updated 2011v6.3 platform concerns 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.

3.4 Spatial Allocation

The methods used to perform spatial allocation are summarized in this section. For the modeling platform, spatial factors are typically applied by county and SCC. As described in Section 0, 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 this updated platform were limited to the addition of SCCs from the MOVES-Mexico inventory to the spatial cross reference for Canada and Mexico. In addition, with 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://newftp.epa.gov/air/emismod/2011/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 3-4 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. Surrogates for ports (801) and shipping lanes (802) were developed based on the 2011NEIv2 shapefiles: Ports_032310_wrf and ShippingLanes_111309FINAL_wrf, but also included shipping lane data in the Great Lakes and support vessel activity data in the Gulf of Mexico. The creation of surrogates and shapefiles for the U.S. was generated via the Surrogate Tool. The tool and documentation.

Table 3-4. 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

Code	Surrogate Description	Code	Surrogate Description
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 3-6)
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*
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*	*Gulf Tug Zone Area*
320	Forest Land	*810*	*Navigable Waterway Activity*
330	Strip Mines/Quarries	*812*	*Midwest Shipping Lanes*
340	*Land*	820	Ports NEI NOx
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 3-5. 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 3-5. 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

Source type	Source Type name	Surrogate ID
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 3-6 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 3-6. 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 2011v6.3 platform, the CMV underway emissions were changed to use surrogate 802. 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 3-4 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 3-7 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 3-7. Selected 2011 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	801	Port Areas	38	48,093	3,687	34,683	1,738
cmv	802	Shipping Lanes	360	589,625	21,516	57,679	15,493
cmv	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	13,031
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

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
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	112,01 6	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	21,915
nonpt	520	Commercial plus Industrial plus Institutional	0	0	0	0	14,965
nonpt	527	Single Family Residential	0	0	0	0	153,528
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

Sector	ID	Description	NH3	NOX	PM2_5	SO2	VOC
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
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. 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 2010 Canadian emissions have been updated in the 2011v6.2 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 3-8. The leading "9" was added to the surrogate codes to avoid duplicate surrogate numbers with U.S. surrogates. 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 3-9. The entries in this table are for the othar sector except for the "MEX Total Road Miles" and the "CAN traffic" rows, which are for the othon sector.

Table 3-8. Canadian Spatial Surrogates

Code	Canadian Surrogate Description	Code	Description
9100	Population	92424	BARLEY
9101	total dwelling	92425	BUCWHT
9103	rural dwelling	92426	CANARY
9106	ALL_INDUST	92427	CANOLA
9111	Farms	92428	CHICPEA
9113	Forestry and logging	92429	CORNGR
9211	Oil and Gas Extraction	92425	BUCWHT
9212	Mining except oil and gas	92430	CORNSI
9221	Total Mining	92431	DFPEAS
9222	Utilities	92432	FLAXSD
9233	Total Land Development	92433	FORAGE
9308	Food manufacturing	92434	LENTIL
9321	Wood product manufacturing	92435	MUSTSD
9323	Printing and related support activities	92436	MXDGRN
9324	Petroleum and coal products manufacturing	92437	OATS
9327	Non-metallic mineral product manufacturing	92438	ODFBNS
9331	Primary Metal Manufacturing	92439	OTTAME
9412	Petroleum product wholesaler-distributors	92440	POTATS
9416	Building material and supplies wholesaler-distributors	92441	RYEFAL
9447	Gasoline stations	92442	RYESPG
9448	clothing and clothing accessories stores	92443	SOYBNS
9481	Air transportation	92444	SUGARB

Code	Canadian Surrogate Description	Code	Description
9482	Rail transportation	92445	SUNFLS
9562	Waste management and remediation services	92446	TOBACO
9921	Commercial Fuel Combustion	92447	TRITCL
9924	Primary Industry	92448	WHITBN
9925	Manufacturing and Assembly	92449	WHTDUR
9932	CANRAIL	92450	WHTSPG
9941	PAVED ROADS	92451	WHTWIN
9942	UNPAVED ROADS	92452	BEANS
9945	Commercial Marine Vessels	92453	CARROT
9946	Construction and mining	92454	GRPEAS
9948	Forest	92455	OTHVEG
9950	Combination of Forest and Dwelling	92456	SWCORN
9955	UNPAVED_ROADS_AND_TRAILS	92457	TOMATO
9960	TOTBEEF	92430	CORNSI
9970	TOTPOUL	92431	DFPEAS
9980	TOTSWIN	92432	FLAXSD
9990	TOTFERT	92433	FORAGE
9996	urban_area	92434	LENTIL
9997	CHBOISQC	92435	MUSTSD
91201	traffic_bcw	92436	MXDGRN
92401	BULLS	92437	OATS
92402	BFCOWS	92438	ODFBNS
92403	BFHEIF	92439	OTTAME
92404	CALFU1	92440	POTATS
92405	FDHEIF	92441	RYEFAL
92406	STEERS	92442	RYESPG
92407	MLKCOW	92443	SOYBNS
92408	MLKHEIF	92444	SUGARB
92409	MBULLS	92445	SUNFLS
92410	MCALFU1	92446	TOBACO
92412	BROILER	92447	TRITCL
92413	LAYHEN	92448	WHITBN
92414	TURKEY	92449	WHTDUR
92416	BOARS	92450	WHTSPG
92417	GRWPIG	92451	WHTWIN
92418	NURPIG	92452	BEANS
92419	SOWS	92453	CARROT
92421	IMPAST	92454	GRPEAS
92422	UNIMPAST	92455	OTHVEG
92423	ALFALFA	92456	SWCORN
		92457	TOMATO

Table 3-9. CAPs Allocated to Mexican and Canadian Spatial Surrogates

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	PM 2_5	SO_2	VOC
10	MEX Population	0	169	5	1	342
12	MEX Housing	21,275	91,275	3,631	389	117,405
14	MEX Residential Heating – Wood	0	1,010	12,952	155	89,051
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	98,576
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	63,021
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
9100	CAN Population	583	19	607	11	243
9101	CAN total dwelling	265	26,700	6,793	4,937	20,769
9103	CAN rural dwelling	1	426	68	2	2,491
9106	CAN ALL_INDUST	6	8,999	348	8	2,738
9111	CAN Farms	26	27,674	2,409	39	3,212
9113	CAN Forestry and logging	576	6,506	352	632	15,352
9211	CAN Oil and Gas Extraction	1	1,640	98	2	141
9212	CAN Mining except oil and gas	0	0	2,074	0	0
9221	CAN Total Mining	37	11,269	41,316	1,217	987
9222	CAN Utilities	60	3,831	305	652	164
9233	CAN Total Land Development	13	12,742	1,362	20	1,983
9308	CAN Food manufacturing	0	0	4,323	0	7,548
9321	CAN Wood product manufacturing	0	0	537	0	0
9323	CAN Printing and related support activities	0	0	0	0	33,802
9324	CAN Petroleum and coal products manufacturing	0	784	835	410	2,751
9327	CAN Non-metallic mineral product manufacturing	0	0	4,362	0	0
9331	CAN Primary Metal Manufacturing	0	142	5,279	46	17
9412	CAN Petroleum product wholesaler-distributors	0	0	0	0	44,248
9448	CAN clothing and clothing accessories stores	0	0	0	0	132
9481	CAN Air transportation	5	7,692	130	787	6,112
9482	CAN Rail transportation	3	4,247	94	136	94
9562	CAN Waste management and remediation services	1,111	1,497	1,837	2,183	13,868
9921	CAN Commercial Fuel Combustion	467	133,157	11,421	29,102	100,571
9924	CAN Primary Industry	0	0	0	0	220,312
9925	CAN Manufacturing and Assembly	0	0	0	0	71,912
9932	CAN CANRAIL	67	62,931	2,373	1,431	1,846

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	PM_{2_5}	SO_2	VOC
9941	CAN PAVED ROADS	2	1,261	158,418	2	2,269
9942	CAN UNPAVED ROADS	21	4,245	1,311	26	57,493
9945	CAN Commercial Marine Vessels	30	40,929	3,360	27,659	5,954
9946	CAN Construction and mining	0	1	9	0	78
9950	CAN Combination of Forest and Dwelling	267	2,899	31,312	424	44,339
9955	CAN UNPAVED_ROADS_AND_TRAILS	0	0	242,537	0	0
9990	CAN TOTFERT	0	0	29,266	0	159,858
9996	CAN urban_area	0	0	618	0	0
9997	CAN CHBOISQC	442	4,912	48,652	702	71,050
91201	CAN traffic_bcw	18,654	345,838	12,226	1,702	178,467
92401	CAN BULLS	4,394	0	0	0	0
92402	CAN BFCOWS	46,101	0	0	0	0
92403	CAN BFHEIF	7,398	0	0	0	0
92404	CAN CALFU1	17,987	0	0	0	0
92406	CAN STEERS	24,551	0	0	0	0
92407	CAN MLKCOW	37,603	0	0	0	0
92408	CAN MLKHEIF	2,617	0	0	0	0
92409	CAN MBULLS	35	0	0	0	0
92410	CAN MCALFU1	11,988	0	0	0	0
92412	CAN BROILER	7,049	0	0	0	0
92413	CAN LAYHEN	8,044	0	0	0	0
92414	CAN TURKEY	3,220	0	0	0	0
92416	CAN BOARS	139	0	0	0	0
92417	CAN GRWPIG	51,078	0	0	0	0
92418	CAN NURPIG	13,047	0	0	0	0
92419	CAN SOWS	5,376	0	0	0	0
92421	CAN IMPAST	1,949	0	0	0	0
92422	CAN UNIMPAST	2,081	0	0	0	0
92423	CAN ALFALFA	1,622	0	0	0	0
92424	CAN BARLEY	7,576	0	0	0	0
92425	CAN BUCWHT	21	0	0	0	0
92426	CAN CANARY	282	0	0	0	0
92427	CAN CANOLA	7,280	0	0	0	0
92428	CAN CHICPEA	449	0	0	0	0
92429	CAN CORNGR	15,655	0	0	0	0
92430	CAN CORNSI	2,328	0	0	0	0
92431	CAN DFPEAS	703	0	0	0	0
92432	CAN FLAXSD	1,667	0	0	0	0
92433	CAN FORAGE	526	0	0	0	0
92434	CAN LENTIL	547	0	0	0	0
92435	CAN MUSTSD	722	0	0	0	0
92436	CAN MXDGRN	658	0	0	0	0
92437	CAN OATS	4,452	0	0	0	0
92438	CAN ODFBNS	254	0	0	0	0
92439	CAN OTTAME	5,985	0	0	0	0

Code	Mexican or Canadian Surrogate Description	NH_3	NO_X	PM $_{2\_5}$	SO_2	VOC
92440	CAN POTATS	1,268	0	0	0	0
92441	CAN RYEFAL	153	0	0	0	0
92442	CAN RYESPG	7	0	0	0	0
92443	CAN SOYBNS	1,775	0	0	0	0
92444	CAN SUGARB	30	0	0	0	0
92445	CAN SUNFLS	383	0	0	0	0
92446	CAN TOBACO	72	0	0	0	0
92447	CAN TRITCL	73	0	0	0	0
92448	CAN WHITBN	288	0	0	0	0
92449	CAN WHTDUR	5,524	0	0	0	0
92450	CAN WHTSPG	13,929	0	0	0	0
92451	CAN WHTWIN	2,785	0	0	0	0
92452	CAN BEANS	109	0	0	0	0
92453	CAN CARROT	73	0	0	0	0
92454	CAN GRPEAS	113	0	0	0	0
92455	CAN OTHVEG	294	0	0	0	0
92456	CAN SWCORN	297	0	0	0	0
92457	CAN TOMATO	98	0	0	0	0

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, fire, and stationary nonpoint source Canadian emissions. 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 2010 emissions inventories for Canada adjusted to approximate 2023 levels. 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.

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. The projected EGU emissions include the Final Mercury and Air Toxics (MATS) rule announced on December 21, 2011, the Cross-State Air Pollution Rule (CSAPR) issued July 6, 2011, and the CSAPR Update Rule issued October 26, 2016. Note that the Clean Power Plan (CPP) is included in the 2023 base case.

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 as described further in Section 4.2.

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. 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): 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, and 2018 emissions modeling platforms, 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): Regional projection factors by production indicators using information from AEO 2016 projections to year 2023. 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.
- 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, and 2018 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.
- 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.
- 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 2010 inventories were projected 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, the Canadian point sources were modified by removing any remaining EGU facilities using coal. For Mexico, the othon inventory data were based on a 2023 run of MOVES-Mexico, while othar and othpt inventory data were interpolated to 2023 between 2018 and 2025. C3 CMV data was projected using the same methodology as the cmv sector. 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 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
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 2018 NODA (search for 'EPA-HQ-OAR-2013-0809' at regulations.gov)	nonpt, ptnonipm, pt_oilgas	PROJECTION & CONTROL	All	4.2.3.5, 4.2.4.10	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

Description of growth, control, closure data, or, new inventory	Sector(s)	Packet Type	CAPs impacted	Section(s)	CoST Strategy
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 2018 NODA (search for 'EPA-HQ-OAR-2013-0809' at regulations.gov)	nonpt, ptnonipm, pt_oilgas	PROJECTION & CONTROL	All	4.2.3.5, 4.2.4.10	1
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					

Description of growth, control, closure data, or, new inventory	Sector(s)	Packet Type	CAPs impacted	Section(s)	CoST Strategy
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 Controls:					
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
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)

The future-year data for the ptegu sector used in the air quality modeling were created by IPM version 5.16. The IPM is a multiregional, dynamic, deterministic linear programming model of the U.S. electric power sector. IPM version 5.16 reflects state rules, consent decrees and announced shutdowns forecast through calendar year 2023. The NEEDS database was updated based on comments received on the notice of data availability for the emissions modeling platform issued prior to the proposal. IPM version 5.16 was updated from the previous version 5.15 and represents electricity demand projections for the AEO 2016. The scenario used for this modeling represents the implementation of the CSAPR Update, CSAPR, MATS, CPP and the final actions the EPA has taken to implement the Regional Haze Rule, the Cooling Water Intakes Rule, and Combustion Residuals from Electric Utilities (CCR).

Directly emitted PM emissions (i.e., $PM_{2.5}$ and PM_{10}) from the EGU sector are computed via a post processing routine that applies emission factors to the IPM-estimated fuel throughput based on fuel, configuration and controls to compute the filterable and condensable components of PM. This postprocessing step also apportions the regional emissions down to the unit-level emissions used for air quality modeling. A single IPM run was postprocessed to get results for 2023.

From the unit-level parsed file, a flat file is created that is used as the input to SMOKE and processed into the format needed by the air quality model. As part of the development of the flat file, a cross reference between the 2011NEIv2 and IPM is used to populate stack parameters and other related information for matched sources. The flat file creation methodology is documented in the air quality modeling flat file documentation. The cross reference is available from the reports directory of the 2011v6.3 platform FTP site: ftp://newftp.epa.gov/air/emismod/2011/v3platform/. The emissions in the flat file created based on the IPM outputs are temporalized into the hourly emissions needed by the air quality model.

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.

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 4-2, although the fields in Table 4-2 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 4-2 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 4-2. 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

Rank	Matching Hierarchy	Inventory Type
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 4-3. Note that future year inventories were used rather than projection or control packets for some sources.

Table 4-3. 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.

Subsection	Title	Sector(s)	Brief Description
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.
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.
4.2.4.10	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.

Subsection	Title	Sector(s)	Brief Description
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.
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)

Packet: "CLOSURES_2011v6_2_v4fix_31aug2015_08jan2016_v5.txt" (ptnonipm)

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

1. Emissions Inventory System (EIS) facilities report from December 20, 2014 with closure status equal to "PS" (permanent shutdown)
2. EIS unit-level report from November 29, 2014 with status = 'PS' (i.e., post-2011 permanent facility/unit shutdowns known in EIS as of the date of the report).
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.
5. Closures provided by MARAMA with 2011v6.3 2023 CoST packets.

Note that no pt_oilgas sources are affected by the current CLOSURES packet. The 2011v6.0 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 closures packets include changes to closure dates for North Carolina, West Virginia and Oklahoma facilities and other changes received as comments on the NODA for the 2011v6.2 platform. These changes impact sources in the ptnonipm and pt_oilgas sectors. The cumulative reductions in emissions for ptnonipm are shown in Table 4-4.

Table 4-4. Reductions from all facility/unit/stack-level closures.

Pollutant	ptnonipm
CO	18,180
NH3	489
NOX	14,023
PM10	4,348

PM2.5	3,114
SO2	36,206
VOC	15,792

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)

Packet:

" 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 projection VMT to year 2023 can be found in section 4.3.

We received comments from the 2018 NODA (EPA-HQ-OAR-2013-0809) 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 4-5. 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 4-5. Increase in total afdust $PM_{2.5}$ emissions from VMT projections

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

4.2.3.2 Livestock population growth (ag)

Packet:

"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. Appendix C provides the animal population data and regression curves used to derive the growth factors.

The national projection factors by animal category and ag sector total impacts are provided in Table 4-6, 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 4-6. 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" as well as the March 2008 "Final locomotive-marine rule" controls. 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)[1]. 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 4-7. 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 4-7. 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

[1] 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 Vehicles and Engines.

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
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, 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, 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.

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 4-8.

Table 4-8. Difference in Category 1& 2 cmv and rail sector emissions between 2011 and 2023,

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.

Projection factors for creating the year 2023 cmv inventory from the 2011 base case are provided in Table 4-9. 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 4-9. 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 4-10.

Table 4-10. 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, 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[2]. 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)[3].

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[4] 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 4-11. 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. See Appendix B for the complete cross-walk between SCC, for all component types of petroleum transport and storage 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 4-11. 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

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

[3] 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.

[4] 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.

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 are 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 4-2.

Table 4-11. Petroleum pipelines & refineries and production storage and transport factors and reductions

Poll	Year	Factors			2011 Emissions	Reduction	% Reduction
		Pipelines & Refineries	RBT	BTP/BPS			
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"

pt_oilgas and np_oilgas sectors:
"projections_np_oilgas_2023_csv_19sep2016_v0.txt"
"projections_pt_oilgas_2023_csv_19sep2016_v0.txt"
"PROJECTION 2011v6.3: 2017_Oklahoma_source_NODA_11jan2016_v1.txt"
"PROJECTION_VA_ME_TCEQ_AL_comments_2011v6_2019"
"PROJECTION_2011v6.2_2025_TCEQ_v6_leftovers_NONPOINT_30jan2015"

MARAMA states:
"BETA_Projections_NP_OILGAS_2023_22apr2016_emf.csv" (MARAMA)
"BETA_Projections_PT_OILGAS_2023_24aug2016_emf.csv" (MARAMA)
"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 EPA-HQ-OAR-2013-0809 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 has 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 approach, 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 4-11 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. That additional data were considered and included in our projections as well, and are discussed separately in Section 4.2.3**Error! Reference source not found.**.

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 AEO2016 reference case production data (label dated "19sep2016").
   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. **(NEW)** 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 4-12. 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.
EPA New projection packets for 2023: "projections_np_oilgas_2023_csv_19sep2016_v0.txt" "projections_pt_oilgas_2023_csv_19sep2016_v0.txt"	Non-MARAMA states using 2016 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 4-12 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 AEO2016 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

The oil and gas sector is rapidly changing in various regions throughout the U.S. To better capture these recent trends and to forecast to year 2023, the AEO 2016 reference case data 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. The National Oil and Gas Supply Table was used to project emissions nationally related to Coalbed Methane and Natural Gas Plant Liquids production. The Lower 48 Crude Oil Production was used to project emissions related to oil production for the six EIA Supply Regions (Figure 4-1) plus offshore regions. The Lower 48 Natural Gas Production Table was used to project emissions related to natural gas dry production for the six EIA Supply Regions plus offshore regions. Table 4-13 shows the projection factors for year 2023 for these EIA Supply Regions for Natural Gas Dry and Oil production. An average of the two factors is also provided. 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, the average projection factor was used for that EIA Supply Region. The states and counties that are part of each EIA Supply Region were defined so that the projection packets generated would include the appropriate FIPS codes.

The MARAMA states provided similar projection packets for oil and gas sectors but used the AEO2015 reference case and used Eastern EIA Supply Region data. MARAMA also assumed no growth for the State of New York in the np_oilgas sector. The net impacts of these projection packets for each of the modeling sectors is provided in Table 4-14.

Table 4-13. Year 2023 projection factors derived from AEO2016 for each EIA Supply Region.

EIA Supply Region	Natural Gas Dry Production	Oil Production	Average Oil and Gas
East	4.777	1.901	3.339

Gulf Coast	1.702	2.069	1.885
Midcontinent	0.855	0.933	0.894
Southwest	0.858	2.071	1.465
Dakotas/Rocky Mtns	0.961	2.997	1.979
West Coast	0.750	0.774	0.762
OFFSHORE	0.652	1.281	0.966

Figure 4-1. Oil and Gas NEMS Regions

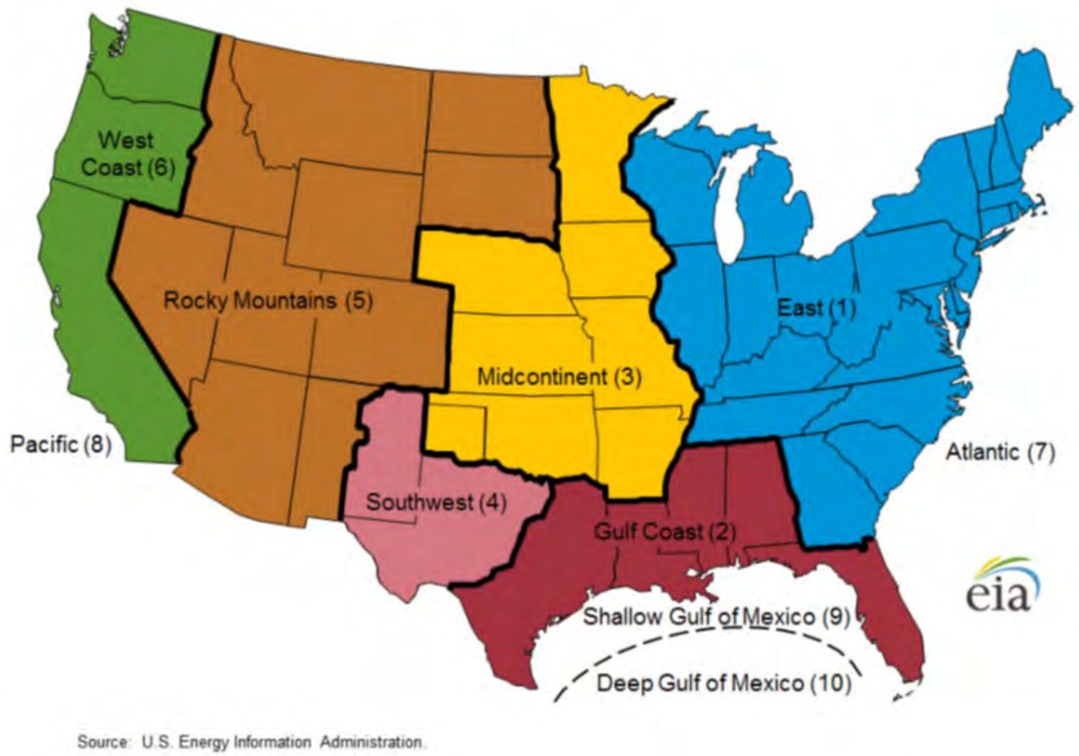


Table 4-14. Industrial source projections net impacts for 2023

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	634,109	1,128,796	494,687	78%
CO	pt_oilgas	233,454	293,484	60,030	26%
CO	ptnonipm	1,053,603	1,178,631	125,027	12%
CO	**Total**	**2,654,405**	**3,391,546**	**737,140**	**28%**
NH_3	nonpt	18,381	18,830	449	2%
NH_3	pt_oilgas	257	244	-13	-5%
NH_3	ptnonipm	12,675	13,569	894	7%
NH_3	**Total**	**31,314**	**32,644**	**1,330**	**4%**
NO_X	nonpt	499,419	517,606	18,187	4%
NO_X	np_oilgas	666,560	1,138,413	471,853	71%
NO_X	pt_oilgas	525,974	593,058	67,084	13%
NO_X	ptnonipm	781,910	888,425	106,515	14%
NO_X	**Total**	**2,473,863**	**3,137,502**	**663,638**	**27%**
PM_{10}	nonpt	280,933	315,788	34,856	12%
PM_{10}	np_oilgas	17,782	31,508	13,726	77%
PM_{10}	pt_oilgas	14,228	16,058	1,830	13%
PM_{10}	ptnonipm	147,376	164,544	17,168	12%
PM_{10}	**Total**	**460,319**	**527,898**	**67,579**	**15%**
$PM_{2.5}$	nonpt	224,860	254,129	29,268	13%
$PM_{2.5}$	np_oilgas	16,331	28,631	12,299	75%
$PM_{2.5}$	pt_oilgas	13,955	15,748	1,794	13%
$PM_{2.5}$	ptnonipm	118,527	134,163	15,636	13%
$PM_{2.5}$	**Total**	**373,673**	**432,670**	**58,997**	**16%**
SO_2	nonpt	253,885	237,039	-16,846	-7%
SO_2	np_oilgas	17,232	42,312	25,080	146%
SO_2	pt_oilgas	60,832	78,892	18,060	30%
SO_2	ptnonipm	540,547	546,037	5,490	1%
SO_2	**Total**	**872,495**	**904,280**	**31,785**	**4%**
VOC	nonpt	1,098,831	1,151,852	53,021	5%
VOC	np_oilgas	2,483,828	4,542,456	2,058,628	83%
VOC	pt_oilgas	147,389	184,212	36,823	25%
VOC	ptnonipm	177,562	202,823	25,262	14%
VOC	**Total**	**3,907,609**	**6,081,343**	**2,173,734**	**56%**

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 (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.

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 4-15.

Table 4-15. 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
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

SCC	Description	FAA ITN Type
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 4-16.

Table 4-16. National aircraft emission projection summary

	Emissions		Difference	% Difference
	2011	2025	2025-2011	2025
CO	489,867	559,797	69,930	4.05%
NO_X	120,968	157,610	36,642	8.85%
PM_{10}	9,165	10,039	874	2.27%
$PM_{2.5}$	7,891	8,709	818	2.46%
SO_2	14,207	18,139	3,932	7.38%
VOC	32,023	38,077	6,054	4.93%

4.2.3.7 Cement manufacturing (ptnonipm)

Packet:

"PROJECTION_2011_2025_ISIS_cement_by_CENSUS_DIVISION.txt"

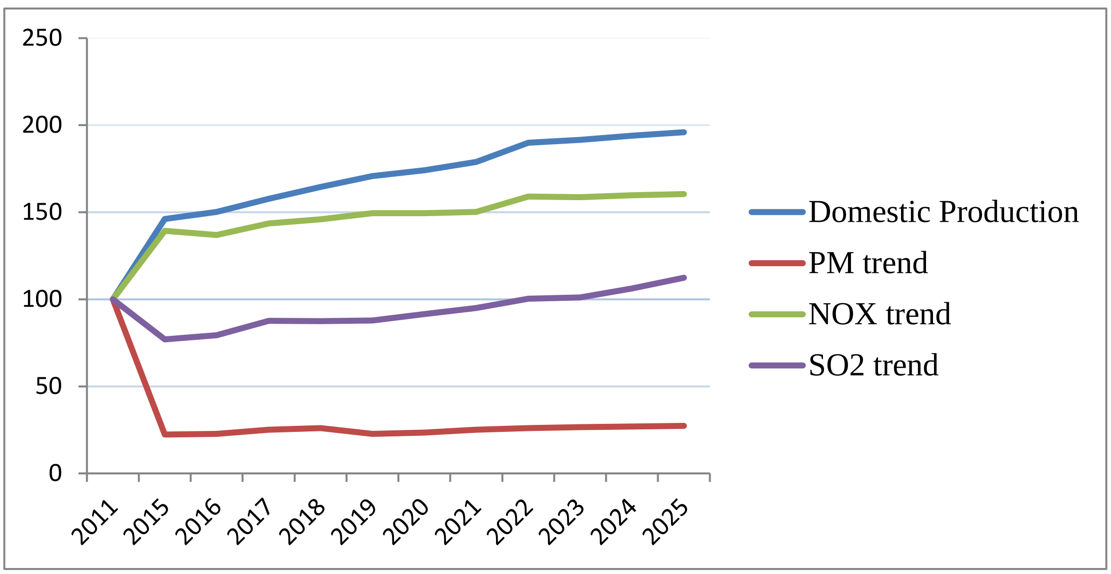
As indicated in Table 4-1, the Industrial Sectors Modeling Platform (ISMP) (EPA, 2010b) was used to project the cement industry component of the ptnonipm emissions modeling sector to 2025; we used year 2025 emissions for year 2023. This approach provided reductions of criteria and select hazardous air 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 4.2.4.10).

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. These aggregate emissions were used to create 2025/2011 emissions ratios for each pollutant and geographic area. The projection ratios, provided in Table 4-17, 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 4-17. 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 4-18 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 4-18.

Table 4-18. ISMP-based cement industry projected emissions

	Emissions		Tons Difference	% Difference
	2011	2025	2025	2025
NO_X	53,240	75,680	22,440	42.10%
PM_{10}	2,954	1,033	-1,921	-65.00%
$PM_{2.5}$	1,709	657	-1,052	-61.60%
SO_2	15,876	25,579	9,702	61.10%
VOC	2,503	1,026	-1,477	-59.00%

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 4-19 provides the summaries of estimated emissions for the corn ethanol plants in 2011 and future year 2025.

Table 4-19. 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. 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). 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 4-20. 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 4-20. 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		
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 4-21. For direct PM, the NSPS emission factor reductions mostly offset the growth in appliances by year 2023.

Table 4-21. 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.

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

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.

Table 4-22 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 4-22. 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)

<u>Packet:</u>
"CONTROL_2023_OILGAS_VOC_NSPS.csv"

"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 4-22, 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 4-23. NSPS VOC oil and gas reductions from projected pre-control 2023 grown values

Region	**Pre-NSPS emissions**	**Post-NSPS emissions**	**NSPS Reductions**	**NSPS % reductions**
Gulf Coast	241,981	69,078	172,903	71%
Midcontinent	203,306	63,180	140,126	69%
New Mexico/Texas*	1,492,201	427,779	1,064,421	71%
Northeast	362,847	116,824	246,024	68%
Rocky Mountains	1,120,805	312,627	808,179	72%
West Coast	106,700	31,432	75,269	71%
Overall	3,527,840	1,020,920	2,506,921	71%

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 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). The "Regulatory Impact Analysis (RIA) for Reconsideration of the Existing Stationary Spark Ignition (SI) RICE NESHAP: Final Report" (EPA, 2013si) is available at:
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 4-24. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-24. 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
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 4-25. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-25. National by-sector reductions from RICE Reconsideration controls (tons)

Pollutant	Year	Nonpoint Oil & Gas (np_oilgas)	Point Oil & Gas (pt_oilgas)	Nonpoint (nonpt)	Point (ptnonipm)	Total
CO	2023	9,934	5,546	3,505	6,443	25,429
NOX	2023	2,500	2,225	216	83	5,025
PM10	2023	0	9	1,038	308	1,355
PM2.5	2023	0	9	913	292	1,214
SO2	2023	0	12	2,951	311	3,274
VOC	2023	2,053	3,710	625	951	7,339

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

Packet:

"CONTROL_2011v6_3_2023_RICE_NSPS_18oct2016"
"BETA_Controls_RICE_NSPS_2023_30jul2016.csv" (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 4-26. 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 4-26. 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 4-26. 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 4-26), no RICE NSPS controls were computed. National RICE NSPS reductions from projected pre-NSPS 2023 inventory is shown in Table 4-27. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-27. National by-sector reductions from RICE NSPS controls (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	284,741	47,013	2,278	99	334,131	994,100	34%
NOX	2023	363,537	113,599	3,903	172	481,211	1,272,286	38%
VOC	2023	2,641	209	0	2	2,852	4,662	61%

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. 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, 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 4-28.

Table 4-28. 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). 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 4-29; 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 4-30; note that New Jersey controls apply only to nonpoint sources and that New York controls vary by fuel for point sources.

Table 4-29. 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 4-30. 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 **Error! Not a valid bookmark self-reference.**. 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. It is worth noting that the SO_2 reductions in the preamble 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 4-31. Summary of ICI Boiler reductions

Year	Pollutant	Emissions Eligible for Control	Controlled (Final) Emissions	Reductions (tons)	% Reductions
CO	2023	72,391	32,305	40,086	55.4%
NOX	2023	118,692	68,865	49,827	42.0%
PM10	2023	66,097	41,687	24,411	36.9%
PM2.5	2023	37,717	26,669	11,048	29.3%
SO2	2023	265,390	53,062	212,328	80.0%
VOC	2023	2,929	1,110	1,819	62.1%

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 4-32. 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 4-33. 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 4-32. 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
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
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
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
New Jersey	Title 7, Chapter 27, Subchapter 9 Sulfur in Fuels 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
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 New York Times and NRDC
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
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
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

Table 4-33. Summary of fuel sulfur rule impacts on SO_2 emissions

Year	Emissions Eligible for Control	Controlled (Final) Emissions	Reductions	% Reductions
2023	90,866	10,064	80,802	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 4-34 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. 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 4-34. 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 4-35. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-35. National by-sector 2023 NO_X reductions from Stationary Natural Gas Turbine NSPS controls

Sector	Pre-NSPS Emissions	NSPS Reductions	NSPS % Reductions
Non-EGU Point (ptnonipm)	15,588	4,225	27%
Point Oil & Gas (pt_oilgas)	71,318	23,253	33%
Total	86,906	27,478	32%

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 4-36.

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 4-36. 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 4-37. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-37. National by-sector NO_X reductions from Process Heaters NSPS controls

Sector	**Pre-NSPS Emissions**	**NSPS Reductions**	**NSPS % Reductions**
Non-EGU Point (ptnonipm)	73,057	20,225	28%
Point Oil & Gas (pt_oilgas)	9,398	2,246	24%
Total	82,455	22,501	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). 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. Baseline and CISWI rule impacts associated with the CISWI rule. 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 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 4-38. This table reflects the impacts of both the MARAMA and non-MARAMA packets.

Table 4-38. Summary of remaining ptnonipm and pt_oilgas reductions

Year	Pollutant	Emissions Eligible for Control	Controlled (Final) Emissions	Reductions	% Reductions
2023	CO	5,885	757	5,128	87.14%
2023	NH3	233	52	182	77.88%
2023	NOX	101,368	50,429	50,938	50.25%
2023	PM10	4,047	1,942	2,105	52.01%
2023	PM2.5	3,619	1,764	1,855	51.26%
2023	SO2	122,115	26,741	95,374	78.10%
2023	VOC	3,104	2,326	778	25.05%

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 4-39. 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 4-39. 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)

<u>New Future year inventory:</u> “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[5,6]. 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 4-40 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 4-40. 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

Table 4-41provides 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 4-41. 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"

[5] U.S. EPA 2014.Regulatory Impact Analysis for Tier 3 Vehicle Emission and Fuel Standards Program. EPA-420-RD-143-0052.
[6] 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.

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 4-42 and Table 4-43 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 4-44 provides the year 2018 cellulosic plant emissions estimates that were used in this year 2023 modeling platform.

Table 4-42. 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 4-43. 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 4-44. 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 (docket # EPA-HQ-OAR-2013-0809), 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 4-42 and Table 4-43. The resulting new facilities and NOx emissions used for year 2023 are provided in Table 4-45. Note that these facilities are in a nonpoint inventory because latitude-longitude coordinates were not available.

Table 4-45. 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 4-46 shows the magnitude of the new ISMP-based cement kilns. ISMP-generated kilns as nonpoint sources only.

Table 4-46. ISMP-generated nonpoint cement kiln emissions

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

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. Local inspection and maintenance (I/M) and other onroad mobile programs are included such as California LEVIII, the National Low Emissions Vehicle (LEV) and Ozone Transport Commission (OTC) LEV regulations, local fuel programs, and Stage II refueling control programs. 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 transportation projections. Trends were developed by calculating ratios between 2017 AEO and 2023 AEO[7] 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 4-47. Note that where states provided 2018 VMT, the 2023 VMT does not exactly equal the 2017 VMT times the ratio.

Table 4-47. Projection factors for 2023 (in millions of miles)[8]

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

[7] By “2017 AEO” and “2023 AEO,” this refers to the AEO2016’s estimates of national VMT in those specific calendar years.

[8] 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.

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, Vermont, Virginia, and Wyoming[9]. 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

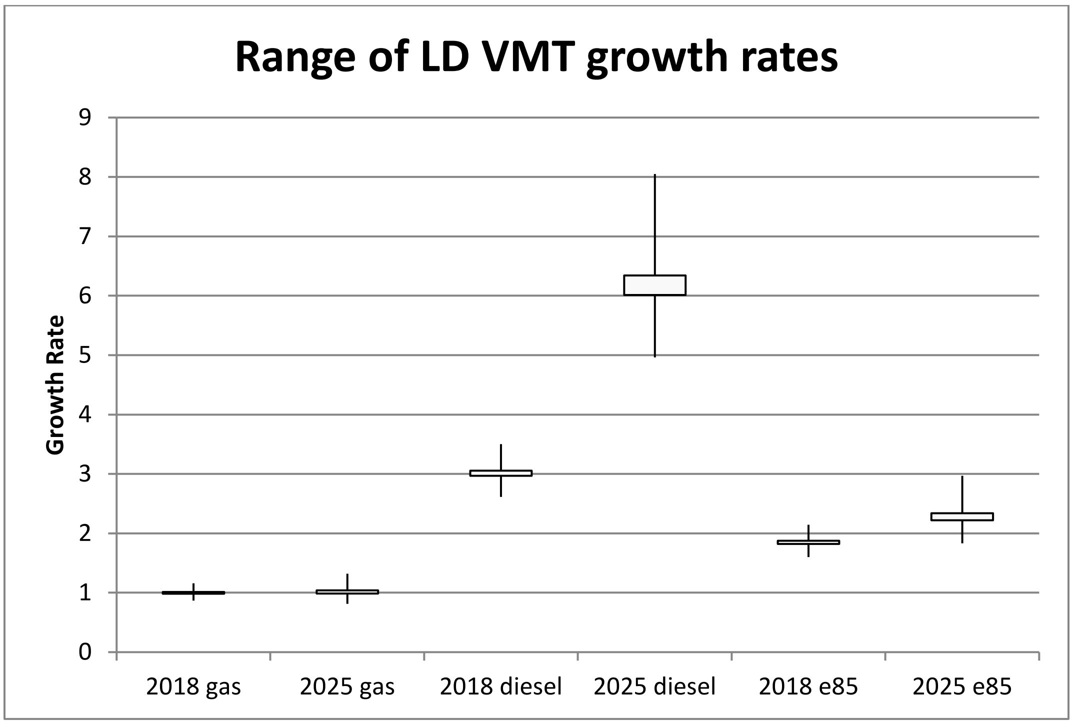
The specific value of D used for EPA projections was 0.5. This was based on an analysis of the growth of LD vehicles over time as compared to human population, which was found to be about 0.5 vehicles per person. The LD growth rates will vary by county, fuel, and year. The range of these growth rates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

[9] 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.

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.

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, 2015), 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 4-48.

Table 4-48. 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 4-49):

Table 4-49. 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 release date May 7th 2014, as well as fuel properties changing as part of the Tier 3 Emissions and Fuel Standards Program. 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
- 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

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

<u>California and Texas nonroad emissions</u>

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 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[10] 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 2.3, emissions from Canada, Mexico, and non-U.S. offshore Category 3 Commercial Marine Vessels (C3 CMV) 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 were projected using U.S. emissions changes by SCC and pollutant (see Tables 5-11 and 5-12). The Canadian point sources in othpt sectors were modified for 2023 by removing the remaining coal EGU plants (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).

As discussed in Section 2.5.1 of the 2011v6.3 platform TSD, the ECA-IMO-based C3 CMV emissions outside of U.S. state waters are processed in the othpt sector. This enables shipping lanes to be represented and for emissions to be treated as elevated sources. These C3 CMV emissions include those assigned to the EEZ (defined as those emissions just beyond U.S. waters approximately 3-10 miles offshore, extending to about 200 nautical miles from the U.S. coastline), and all other offshore emissions. The projection factors for the othpt C3 CMV emissions vary by geographic and region as shown in Table 4-9.

[10] 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	70,498	232	414,099	19,658	18,124	91,209	12,584
nonpt	1,645,989	94,242	720,454	491,825	404,258	276,332	3,671,898
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	792,397	25,066	2,095,119	283,072	208,129	4,670,569	38,062
ptnonipm	2,297,650	66,051	1,213,528	477,387	320,857	1,049,424	801,188
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	**69,844,278**	**4,182,913**	**14,163,826**	**11,258,767**	**4,599,665**	**6,403,986**	**17,160,045**
Offshore to EEZ	176,645	189	906,088	26,451	24,741	139,246	81,749
Non-US SECA C3	16,207	0	190,904	16,226	14,926	120,340	6,879
Canada othafdust				780,456	112,597		
Canada othar	3,015,514	326,281	361,958	159,054	131,167	70,276	886,419
Canada othon	3,032,193	18,655	345,657	12,216	5,412	1,702	178,440
Canada othpt	496,083	13,069	266,912	70,009	29,166	544,504	129,119
Canada ptfire_mxca	798,710	13,037	14,048	87,398	73,401	6,481	194,844
Mexico othar	185,229	168,021	181,716	90,559	42,491	10,173	419,249
Mexico othon	1,466,960	2,154	361,626	8,772	3,252	4,428	134,867
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	**10,077,739**	**558,933**	**2,993,679**	**1,414,590**	**570,141**	**1,375,391**	**2,260,852**

* "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	76,265	235	280,626	7,513	7,039	6,811	12,880
nonpt	1,682,696	94,695	735,016	509,892	427,719	96,043	3,454,250
np_oilgas	835,955	0	772,886	31,510	28,632	42,313	2,114,826
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	710,281	41,879	888,542	181,229	136,612	1,165,674	30,745
ptnonipm	2,376,516	66,243	1,211,582	482,565	327,502	797,587	808,390
pt_oilgas	243,841	5,934	448,133	16,551	15,865	84,942	187,955
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	**53,961,563**	**4,247,885**	**7,958,204**	**11,746,487**	**4,432,829**	**2,399,640**	**13,979,755**
Offshore to EEZ	205,441	189	717,820	9,658	9,152	11,619	92,477
Non-US SECA C3	27,810	0	266,354	10,233	9,372	69,593	11,843
Canada othafdust				780,456	112,597		
Canada othar	3,130,776	326,337	290,025	151,257	123,523	70,176	824,416
Canada othon	1,348,633	12,001	116,704	5,110	6,146	983	65,716
Canada othpt	489,410	13,060	247,646	68,377	28,291	497,429	129,119
Canada ptfire_mxca	798,710	13,037	14,048	87,398	73,401	6,481	194,844
Mexico othar	215,759	166,718	209,943	95,309	46,135	12,144	503,620
Mexico othon	1,533,904	2,853	374,074	9,571	4,584	6,364	141,276
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	**8,686,260**	**553,446**	**2,644,438**	**1,393,035**	**555,166**	**1,042,413**	**2,216,430**

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	70,498	76,265	8%
nonpt	1,645,989	1,682,696	2%
np_oilgas	635,942	835,955	31%
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	792,397	710,281	-10%
ptnonipm	2,297,650	2,376,516	3%
pt_oilgas	235,162	243,841	4%
rail	122,703	145,627	19%
rwc	2,517,844	2,368,934	-6%
Con U.S. Total	**69,844,278**	**53,961,563**	**-23%**
Offshore to EEZ	176,645	205,441	16%
Non-US SECA C3	16,207	27,810	72%
Canada othafdust	0	0	0%
Canada othar	3,015,514	3,130,776	4%
Canada othon	3,032,193	1,348,633	-56%
Canada othpt	496,083	489,410	-1%
Canada ptfire_mxca	798,710	798,710	0%
Mexico othar	185,229	215,759	16%
Mexico othon	1,466,960	1,533,904	5%
Mexico othpt	153,387	199,007	30%
Mexico ptfire_mxca	736,810	736,810	0%
Non-US Total	**10,077,739**	**8,686,260**	**-14%**

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	232	235	2%
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	41,879	67%
ptnonipm	66,051	66,243	0%
pt_oilgas	5,947	5,934	0%
rail	347	376	8%
rwc	19,693	18,499	-6%
Con U.S. Total	**4,182,913**	**4,247,885**	**2%**
Offshore to EEZ	189	189	0%
Non-US SECA C3	0	0	0%
Canada othafdust	0	0	0%
Canada othar	326,281	326,337	0%
Canada othon	18,655	12,001	-36%
Canada othpt	13,069	13,060	0%
Canada ptfire_mxca	13,037	13,037	0%
Mexico othar	168,021	166,718	-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	**558,933**	**553,446**	**-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	414,099	280,626	-32%
nonpt	720,454	735,016	2%
np_oilgas	667,068	772,886	16%
nonroad	1,630,301	856,831	-47%
onroad	5,708,150	1,786,856	-69%
ptfire	333,398	333,398	0%
ptegu	2,095,119	888,542	-58%
ptnonipm	1,213,528	1,211,582	0%
pt_oilgas	509,856	448,133	-12%
rail	791,381	563,382	-29%
rwc	34,436	34,918	1%
Con U.S. Total	**14,163,826**	**7,958,204**	**-44%**
Offshore to EEZ	906,088	717,820	-21%
Non-US SECA C3	190,904	266,354	40%
Canada othafdust	0	0	0%
Canada othar	361,958	290,025	-20%
Canada othon	345,657	116,704	-66%
Canada othpt	266,912	247,646	-7%
Canada ptfire_mxca	14,048	14,048	0%
Mexico othar	181,716	209,943	16%
Mexico othon	361,626	374,074	3%
Mexico othpt	333,368	376,422	13%
Mexico ptfire_mxca	31,403	31,403	0%
Non-US Total	**2,993,679**	**2,644,438**	**-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	18,124	7,039	-61%
nonpt	404,258	427,719	6%
np_oilgas	16,333	28,632	75%
nonroad	154,657	78,858	-49%
onroad	188,925	79,527	-58%
ptfire	1,844,263	1,844,263	0%
ptegu	208,129	136,612	-34%
ptnonipm	320,857	327,502	2%
pt_oilgas	13,935	15,865	14%
rail	23,963	13,165	-45%
rwc	381,252	362,651	-5%
Con U.S. Total	**4,599,665**	**4,432,829**	**-4%**
Offshore to EEZ	24,741	9,152	-63%
Non-US SECA C3	14,926	9,372	-37%
Canada othafdust	112,597	112,597	0%
Canada othar	131,167	123,523	-6%
Canada othon	5,412	6,146	14%
Canada othpt	29,166	28,291	-3%
Canada ptfire_mxca	73,401	73,401	0%
Mexico othar	42,491	46,135	9%
Mexico othon	3,252	4,584	41%
Mexico othpt	45,963	54,940	20%
Mexico ptfire_mxca	87,025	87,025	0%
Non-US Total	**570,141**	**555,166**	**-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	19,658	7,513	-62%
nonpt	491,825	509,892	4%
np_oilgas	17,784	31,510	77%
nonroad	162,417	84,153	-48%
onroad	326,900	232,752	-29%
ptfire	2,171,987	2,171,987	0%
ptegu	283,072	181,229	-36%
ptnonipm	477,387	482,565	1%
pt_oilgas	14,585	16,551	13%
rail	25,898	14,236	-45%
rwc	381,476	362,897	-5%
Con U.S. Total	**11,258,767**	**11,746,487**	**4%**
Offshore to EEZ	26,451	9,658	-63%
Non-US SECA C3	16,226	10,233	-37%
Canada othafdust	780,456	780,456	0%
Canada othar	159,054	151,257	-5%
Canada othon	12,216	5,110	-58%
Canada othpt	70,009	68,377	-2%
Canada ptfire_mxca	87,398	87,398	0%
Mexico othar	90,559	95,309	5%
Mexico othon	8,772	9,571	9%
Mexico othpt	59,325	71,542	21%
Mexico ptfire_mxca	104,125	104,125	0%
Non-US Total	**1,414,590**	**1,393,035**	**-2%**

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	91,209	6,811	-93%
nonpt	276,332	96,043	-65%
np_oilgas	17,232	42,313	146%
nonroad	4,031	2,380	-41%
onroad	28,195	12,114	-57%
ptfire	165,773	165,773	0%
ptegu	4,670,569	1,165,674	-75%
ptnonipm	1,049,424	797,587	-24%
pt_oilgas	66,577	84,942	28%
rail	7,936	340	-96%
rwc	8,954	7,908	-12%
Con U.S. Total	**6,403,986**	**2,399,640**	**-63%**
Offshore to EEZ	139,246	11,619	-92%
Non-US SECA C3	120,340	69,593	-42%
Canada othafdust	0	0	0%
Canada othar	70,276	70,176	0%
Canada othon	1,702	983	-42%
Canada othpt	544,504	497,429	-9%
Canada ptfire_mxca	6,481	6,481	0%
Mexico othar	10,173	12,144	19%
Mexico othon	4,428	6,364	44%
Mexico othpt	471,847	361,230	-23%
Mexico ptfire_mxca	6,394	6,394	0%
Non-US Total	**1,375,391**	**1,042,413**	**-24%**

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	12,584	12,880	2%
nonpt	3,671,898	3,454,250	-6%
np_oilgas	2,482,590	2,114,826	-15%
nonroad	2,024,419	1,177,147	-42%
onroad	2,713,181	987,796	-64%
ptfire	4,688,094	4,688,094	0%
ptegu	38,062	30,745	-19%
ptnonipm	801,188	808,390	1%
pt_oilgas	164,098	187,955	15%
rail	40,851	21,384	-48%
rwc	442,541	415,748	-6%
Con U.S. Total	**17,160,045**	**13,979,755**	**-19%**
Offshore to EEZ	81,749	92,477	13%
Non-US SECA C3	6,879	11,843	72%
Canada othafdust	0	0	0%
Canada othar	886,419	824,416	-7%
Canada othon	178,440	65,716	-63%
Canada othpt	129,119	129,119	0%
Canada ptfire_mxca	194,844	194,844	0%
Mexico othar	419,249	503,620	20%
Mexico othon	134,867	141,276	5%
Mexico othpt	57,090	80,922	42%
Mexico ptfire_mxca	172,196	172,196	0%
Non-US Total	**2,260,852**	**2,216,430**	**-2%**

Table 5-10. Canadian province 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)
Province	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Newfoundland	70,094	30,838	-56.0%	7,915	2,677	-66.2%	3,333	1,200	-64.0%
Prince Edward Island	24,124	10,745	-55.5%	3,319	1,173	-64.7%	1,390	508	-63.5%
Nova Scotia	119,570	53,151	-55.5%	13,799	4,731	-65.7%	6,593	2,411	-63.4%
New Brunswick	129,867	57,582	-55.7%	18,604	6,672	-64.1%	7,621	2,803	-63.2%
Quebec	885,568	402,179	-54.6%	106,445	37,055	-65.2%	48,478	18,206	-62.4%
Ontario	1,189,550	530,264	-55.4%	124,063	41,172	-66.8%	61,637	23,130	-62.5%
Manitoba	226,661	98,746	-56.4%	27,249	9,459	-65.3%	14,285	5,101	-64.3%
Saskatchewan	353,836	152,184	-57.0%	41,393	14,230	-65.6%	25,123	8,791	-65.0%
Alberta	658,481	287,868	-56.3%	94,080	32,364	-65.6%	48,414	17,262	-64.3%
British Columbia	588,527	256,809	-56.4%	67,944	21,711	-68.0%	45,044	16,189	-64.1%
Yukon	7,590	3,352	-55.8%	686	223	-67.6%	476	171	-64.0%
N W Territories	6,617	2,957	-55.3%	754	264	-64.9%	410	149	-63.7%
Nunavut	1,920	804	-58.1%	155	50	-67.8%	104	35	-65.9%
Canada Total	4,262,403	1,887,476	-55.7%	506,406	171,781	-66.1%	262,908	95,956	-63.5%

Table 5-11. Canadian province 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)
Province	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Newfoundland	71,720	67,816	-5.4%	32,106	29,590	-7.8%	24,884	19,857	-20.2%
Prince Edward Island	27,420	28,106	2.5%	1,309	1,117	-14.6%	7,459	6,156	-17.5%
Nova Scotia	108,892	113,205	4.0%	34,093	31,813	-6.7%	31,588	30,246	-4.2%
New Brunswick	76,757	78,695	2.5%	12,057	10,813	-10.3%	27,446	26,575	-3.2%
Quebec	923,750	953,313	3.2%	96,533	81,444	-15.6%	274,657	261,356	-4.8%
Ontario	1,537,669	1,607,612	4.5%	169,367	138,266	-18.4%	388,132	355,105	-8.5%
Manitoba	153,099	158,768	3.7%	16,943	15,131	-10.7%	67,697	61,035	-9.8%
Saskatchewan	470,108	484,491	3.1%	53,501	37,220	-30.4%	132,559	112,022	-15.5%
Alberta	339,458	324,040	-4.5%	141,209	94,161	-33.3%	205,096	195,910	-4.5%
British Columbia	430,751	433,724	0.7%	103,465	91,799	-11.3%	122,900	118,689	-3.4%
Yukon	1,355	1,250	-7.7%	524	354	-32.4%	702	664	-5.4%
N W Territories	9,214	8,380	-9.1%	4,736	3,309	-30.1%	2,199	1,645	-25.2%
Nunavut	978	774	-20.8%	1,438	975	-32.2%	658	617	-6.2%
Canada Total	4,151,170	4,260,172	2.6%	667,282	535,990	-19.7%	1,285,976	1,189,878	-7.5%

Table 5-12. Canadian province 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)**
Province	CO	CO	CO	NOX	NOX	NOX	VOC	VOC	VOC
Newfoundland	13,073	13,073	0.0%	23,646	23,646	0.0%	19,926	19,926	0.0%
Prince Edward Island	49	49	0.0%	321	321	0.0%	417	417	0.0%
Nova Scotia	4,451	4,451	0.0%	25,181	25,181	0.0%	11,346	11,346	0.0%
New Brunswick	28,314	28,310	0.0%	16,900	16,804	-0.6%	4,691	4,691	0.0%
Quebec	472,250	471,057	-0.3%	52,177	50,554	-3.1%	65,053	64,141	-1.4%
Ontario	85,168	79,696	-6.4%	90,405	72,773	-19.5%	121,838	121,747	-0.1%
Manitoba	2,394	2,394	0.0%	3,822	3,822	0.0%	30,505	30,505	0.0%
Saskatchewan	27,496	27,496	0.0%	65,439	65,439	0.0%	169,269	169,269	0.0%
Alberta	496,794	496,794	0.0%	575,981	575,981	0.0%	498,580	498,580	0.0%
British Columbia	196,308	196,308	0.0%	89,526	89,526	0.0%	56,938	56,938	0.0%
Yukon	50	50	0.0%	135	135	0.0%	5	5	0.0%
N W Territories	1,871	1,871	0.0%	9,107	9,107	0.0%	1,037	1,037	0.0%
Nunavut	817	817	0.0%	5,588	5,588	0.0%	326	326	0.0%
Canada Total	1,329,036	1,322,367	-0.5%	958,229	938,876	-2.0%	979,932	978,928	-0.1%

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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