Oct 15, 2019

SPECIFICATION SHEET: PTNONIPM

Description: Point non-EGU (ptnonipm) emissions, for simulating 2016 U.S. air quality

1. EXECUTIVE SUMMARY

This document details the approach and data sources to be used for developing 2016 emissions for the point non-EGU (ptnonipm) sector, which consists of all US point source emissions which are not electric generating units (EGUs) or associated with oil and gas activity. The primary data source is the 2016 point source National Emissions Inventory (NEI), with airport emissions projected from 2014NEIv2 to 2016 using Federal Aviation Administration (FAA) data, and rail yard emissions provided by the National Emissions Collaborative rail work group. Projection methods for ptnonipm are in process. Base year inventories were processed into a format that can be input to air quality models with the Sparse Matrix Operating Kernel Emissions (SMOKE) modeling system v4.6. National and state-level emission summaries for key pollutants are provided.

2. Introduction

The starting point for the 2016v1 platform ptnonipm inventory is the 2016 point source National Emissions Inventory (NEI). The full point inventory was first "sectorized" into separate components for ptegu, ptnonipm, and pt_oilgas. The ptnonipm component consists of sources which are not EGUs (i.e., the IPM_YN field is blank) and which do not have a NAICS code corresponding to oil and gas exploration, production, or distribution. A list of all NAICS codes in the pt_oilgas sector is provided in the pt_oilgas document.

For some ptnonipm sources, state, local, and tribal agencies submitted updated data that represented calendar year 2016. Submissions to the NEI are required every year for the larger "Type A" sources, but data submitters may optionally submit interim year emissions for additional sources at their discretion. The 2016 submissions and the sources carried forward from the 2014NEIv2 were compiled with additional updates. Further inventory preparation steps are outlined in the next section.

There are nearly 5,000 unique SCCs in the ptnonipm sector, so a full table of SCCs is not included in this document at this time.

3. Inventory Development Methods

2016 point inventory

The 2016 ptnonipm inventory includes both sources with updated data for 2016, and sources carried forward from the 2014NEIv2 point inventory. Of the approximately 63,000 non-airport facilities in the 2014NEIv2 ptnonipm sector, 22,000 of them reported emissions for 2016. The ptnonipm sources (i.e., not EGUs and non oil and gas sources) were used as-is for the 2016v1, with the following exceptions:

- Additional closures were applied in Alabama, Florida, Massachusetts, New York, North Carolina, Ohio, and Virginia based on state comments.
- The District of Columbia (DC) submitted an entire non-EGU point inventory that was used to replace all previously reported non-EGU point emissions.
- Emissions were updated for West Virginia Type B facilities.
- Emissions were updated for a few facilities in Georgia.
- The emission not reported for 2016 from the states that are members of the Mid-Atlantic Regional Air Management Association (MARAMA: Delaware, the District of

Columbia, Maryland, New Jersey, North Carolina, Pennsylvania, Virginia, and West Virginia) were grown from 2014NEIv2 to 2016 using submitted growth factors from MARAMA. An exception to this is that all New Jersey sources not reported in 2016 were removed from the base year inventory.
- Emissions from rail yards were derived from the National Emissions Collaborative rail workgroup.
- Emissions from biorefineries that either were not open in 2014 but were open in 2016, or were not included in the 2014 NEI (e.g. due to emissions below level required to include), or where we had updated information on 2016 volumes that differed from 2014 volumes

Rail yard emissions

Rail yard emissions for 2016v1 platform were provided by the rail workgroup. Emissions were provided in Flat File 2010 (FF10) point format and used directly in SMOKE modeling. These emissions replace all rail yard emissions from the 2016 EIS-based point inventory, and also replace all rail yard emissions from the nonpoint rail sector. The rail specification sheet has more information on how rail yard emissions were developed.

Biorefinery emissions

Biorefinery emissions that had not been included in the 2014 platform were created using upstream modules. Upstream modules are housed within EMF and assisted in developing projection packets and in some cases stand-alone inventories related to producing or transporting mobile source fuels. Emissions were provided in Flat File 2010 (FF10) point format and used directly in SMOKE modeling. Biorefinery emissions that were included in the 2014 platform but where updated volume information was available for 2016 were calculated using projection factors based on upstream modules. First emission factors were calculated for 2016 and then the inventory was projected using projection packets.

4. ANCILLARY DATA

Spatial Allocation / Vertical Allocation

Spatial allocation of ptnonipm emissions to the national 36km and 12km domains used for air quality modeling was based on latitude and longitude data from the point source inventory.

Related to vertical allocation and plume rise, the point source stack replacement parameters (PSTK) file was updated for v1 platform. This file provides default stack parameters by SCC for sources whose stack parameters are missing or blank in the emissions inventory. In alpha platform, we discovered that many fugitive point sources, which ideally would remain in Layer

1, have missing stack parameters and were receiving default stack parameters from the PSTK. These default stack parameters occasionally caused fugitive sources to have plume rise above Layer 1. The PSTK was edited for v1 platform so that default stack parameters for fugitive SCCs do not cause plume rise above Layer 1.

Temporal Allocation

Reports summarizing total emissions according to the monthly, day-of-week, and hour-of-day temporal profile assignments were developed at the state and county level. They are too large to include in this document. However, plots of the diurnal, weekly, and monthly temporal profiles for airport SCCs are shown in Figures 1 through 3.

Figure 1. Diurnal Profile for all Airport SCCs

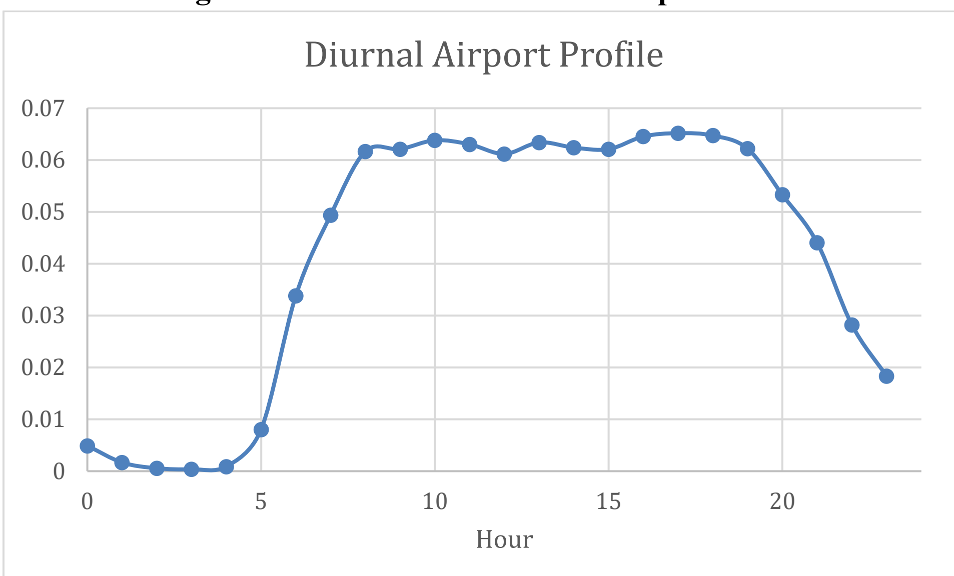


Figure 2. Weekly profile for all Airport SCCs

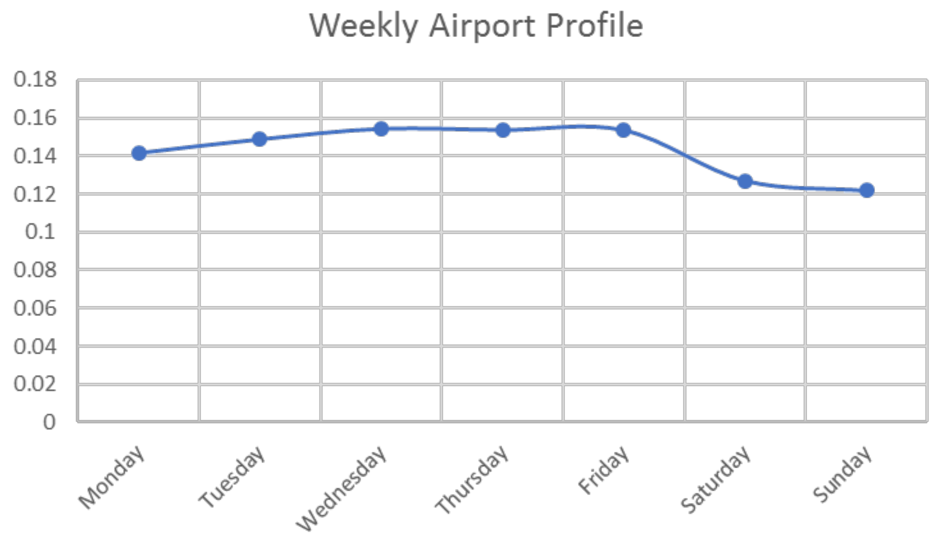
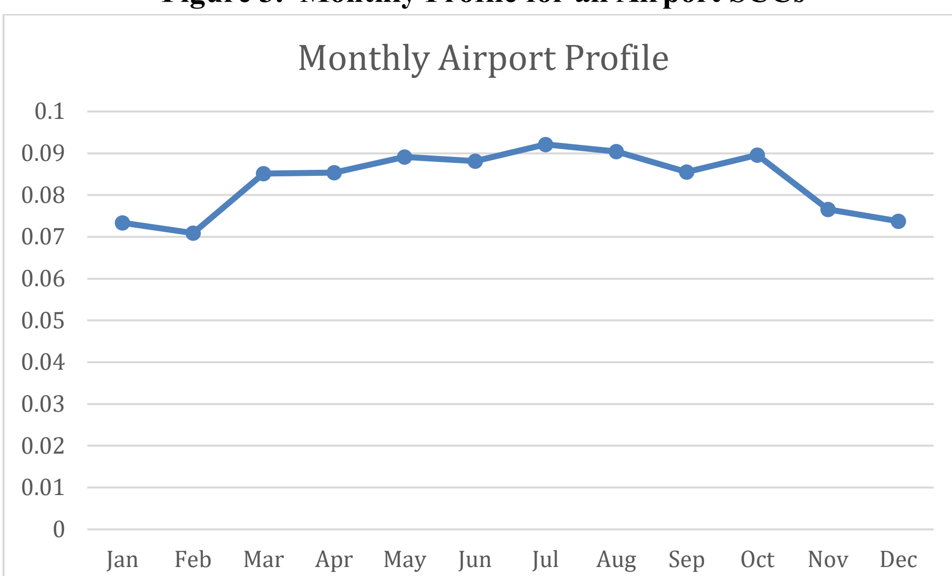


Figure 3. Monthly Profile for all Airport SCCs



Chemical Speciation

The ptnonipm sector includes speciation of PM2.5 and VOC emissions, and does not use HAP integration for VOCs. Reports summarizing total PM2.5 and VOC emissions according to speciation profile were developed at the state and county level and are too large to include in this document.

5. EMISSIONS PROJECTION METHODS

The Control Strategy Tool (CoST) was used to apply facility closures, projection/growth factors and controls to emissions modeling inventories to create future year inventories for ptnonipm sector emissions. Information about CoST and related data sets is available from https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-analysis-modelstools-air-pollution. CoST allows the user to apply projection (growth) factors, controls and closures at various geographic and inventory key field resolutions. Each of these CoST datasets, also called "packets" or "programs," provides the user with the ability to perform numerous quality assurance assessments as well as create SMOKE-ready future year inventories. Future year inventories are created for each emissions modeling sector via a CoST "strategy" and each strategy includes all base year 2016 inventories and applicable CoST packets. CoST uses three packet types as described below:

1. CLOSURE: If applicable, it is 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.
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 2016 emissions inventories prior to the application of any possible subsequent CONTROLs. A PROJECTION packet is desirable when information is based more on activity assumptions rather than known control measures.
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.

Future year projections for the ptnonipm sources of the 2016v1 platform were generated for years 2023 and 2028. These projections consisted of three components: (1) applying facility closures using CLOSURE packet, (2) using historical and/or forecast activity data to generate future-year emissions before applicable control technologies are applied (PROJECTION or growth factors component) and (3) estimating impacts of applicable control technologies on future-year emissions (CONTROL factors component).

Closures

A list of facilities with closure dates of 2016 and later were retrieved from EPA's Emissions Inventory System, including facilities that closed mid-year 2016. This list also includes closures submitted by Alabama, North Carolina, Ohio, Pennsylvania, and Virginia.

Growth

The 2023 and 2028 ptnonipm projections involved several growth and projection methods described here. The projection of all oil and gas sources is explained in the oil and gas specification sheet and will not be discussed in these methods.

2023 and 2028 Point Inventory - inside MARAMA region

2016-to-2023 and 2016-to-2028 projection packets for point sources were provided by MARAMA for the following states: CT, DE, DC, ME, MD, MA, NH, NJ, NY, NC, PA, RI, VT, VA, and WV.

The MARAMA projection packets were used throughout the MARAMA region, except in North Carolina, New Jersey, and Virginia. Those three states provided their own projection packets for the ptnonipm sector, and those projection packets were used instead of the MARAMA packets in those states. The Virginia growth factors for one facility were edited to incorporate emissions limits provided by MARAMA for that facility.

2023 and 2028 Point Inventory - outside MARAMA region

The Energy Information Administration's (EIA) Annual Energy Outlook (AEO) for year 2019 was used as a starting point for projecting industrial sources in this sector. SCC's were mapped to AEO categories and projection factors were created using a ratio between the base year and projection year estimates from each specific AEO category. Table 1 below details the 2019 AEO tables used to map SCCs to AEO categories for the projections of industrial sources. Depending on the category, a projection factor may be national or regional. The maximum projection factor was capped at a factor of 1.25 and the minimum projection factor was capped at 0.5. MARAMA states were not projected using this method, nor were aircraft and rail sources.

An SCC-NAICS projection was also developed using AEO 2019. SCC/NAICS combinations with emissions >100tons/year for any CAP were mapped to AEO sector and fuel. Projection factors for this method were capped at a maximum of 2.5 and a minimum of 0.5.

Table 1. EIA's 2019 Annual Energy Outlook (AEO) tables used to project industrial sources

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

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

Biorefinery Emissions

Some inventories were generated using recently developed modules ("upstream modules") that are housed within the EMF. These modules assisted in developing projection packets, or in some cases stand-alone inventories, related to producing or transporting mobile source fuels. Biorefinery emissions were projected to 2023 and 2028 using the Energy Information Administration's (EIA) Annual Energy Outlook (AEO) for year 2018 as a starting point for projected volumes of biofuels in 2028. These biofuel volumes were used to calculate inventories associated with biorefineries in 2016 and 2028. Those emission inventories were mapped to the appropriate SCCs, and facility-specific projection packets were generated from 2016 to 2023 and 2016 to 2028 applied to biorefinery facilities, both inside and outside the MARAMA region.

Evaporative Emissions from Transport of Finished Fuels

Estimates on growth of evaporative emissions from transporting finished fuels are partially covered in the nonpoint and point oil and gas projection packets. However, there are some processes with evaporative emissions from storing and transporting finished fuels which are not included in the nonpoint and point oil and gas projection packets. The Energy Information Administration's (EIA) Annual Energy Outlook (AEO) for year 2018 was used as a starting point for projecting volumes of finished fuel that would be transported in future years, e.g. 2023 and 2028. Then these volumes were used to calculate inventories associated with evaporative emissions in 2016, 2023, and 2028. Those emission inventories were mapped to the appropriate SCCs and projection packets were generated from 2016 to 2023 and 2016 to 2028. The work to generate the inventories and projection packets happened within modules in the EMF. Sources within the MARAMA region were not projected with these factors, but with the MARAMA-provided growth factors.

Rail Yard Emissions

Projected emissions for rail yards (SCC 28500201) were provided by the rail workgroup. Emissions were provided in Flat File 2010 (FF10) point format and used directly in SMOKE modeling. This method is described further in the Rail Sector specification sheet.

Control

New Source Performance Standards (NSPS)

The final step in the projection of emissions to a future year is the application of any control technologies or programs. For future-year New Source Performance Standards (NSPS) controls (e.g. Reciprocating Internal Combustion Engines (RICE), Natural Gas Turbines, and Process Heaters), we attempted to control only new sources/equipment using the following equation to account for growth and retirement of existing sources and the differences between the new and existing source emission rates.

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

where:

Qn = emissions in projection year
Qo = emissions in base year
Pf = growth rate expressed as ratio (e.g., 1.5=50 percent cumulative growth)
t = number of years between base and future years
Fn = emission factor ratio for new sources
Ri = retirement rate, expressed as whole number (e.g., 3.3 percent=0.033)
Fe = emission factor ratio for existing sources

The first term in Equation 1 represents new source growth and controls, the second term accounts for retirement and controls for existing sources, and the third term accounts for replacement source controls.   For computing the CoST % reductions (Control Efficiency), the simplified Equation 2 was used for 2023 and 2028 projections:

$Control\_Efficiency_{2028}(\%) = 100 * (1- [(Pf_{2028}-1)*Fn + (1-Ri)^{12} + (1-(1-Ri)^{12})*Fn]/ Pf_{2028})$ ***Equation 2***

Here, the existing source emissions factor (Fe) is set to 1.0, 2028 (future year) minus 2016 (base year) is 12 years or 2023 minus 2016 is 8 years, and new source emission factor (Fn) is the ratio of the NSPS emission factor to the existing emission factor. Table 2 shows the values for Retirement rate and new source emission factors (Fn) for new sources with respect to each NSPS regulation and other conditions within. For the ptnonipm sector, the RICE NSPS, Process Heaters NSPS, and Natural Gas Turbines NSPS control programs were applied when estimating year 2023 and 2028 emissions for the 2016v1 modeling modelling platform. Further information about the application of NSPS controls can be found in Section 4 of the *Additional Updates to Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform for the Year 2023* technical support document (https://www.epa.gov/sites/production/files/2017-11/documents/2011v6.3_2023en_update_emismod_tsd_oct2017.pdf).

Table 2. Assumed retirement rates and new source emission factor ratios for NSPS rules

NSPS Rule	Sector(s)	Retirement Rate years (%/year)	Pollutant Impacted	Applied where?	New Source Emission Factor (Fn)
Oil and Gas	np_oilgas, pt_oilgas	No assumption	VOC	Storage Tanks: 70.3% reduction in growth-only (>1.0)	0.297
				Gas Well Completions: 95% control (regardless)	0.05
				Pneumatic controllers, not high-bleed >6scfm or low-bleed: 77% reduction in growth-only (>1.0)	0.23
				Pneumatic controllers, high-bleed >6scfm or low-bleed: 100% reduction in growth-only (>1.0)	0.00
				Compressor Seals: 79.9% reduction in growth-only (>1.0)	0.201
				Fugitive Emissions: 60% Valves, flanges, connections, pumps, open-ended lines, and other	0.40
				Pneumatic Pumps: 71.3%; Oil and Gas	0.287
RICE	np_oilgas, pt_oilgas, ptnonipm, nonpt	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

NSPS Rule	Sector(s)	Retirement Rate years (%/year)	Pollutant Impacted	Applied where?	New Source Emission Factor (Fn)
				Rich Burn: PA, all other states	0.1, n/a
				Combined (average) LB/RB: PA, other states	0.1125, n/a
Gas Turbines	pt_oilgas, ptnonipm	45 (2.2%)	NO_X	California and NO_X SIP Call states	0.595
				All other states	0.238
Process Heaters	pt_oilgas, ptnonipm	30 (3.3%)	NO_X	Nationally to Process Heater SCCs	0.41

RICE NSPS

For RICE NSPS controls, the EPA emission requirements for stationary engines differ according to whether the engine is new or existing, whether the engine is located at an area source or major source, and whether the engine is a compression ignition or a spark ignition engine. Spark ignition engines are further subdivided by power cycle, two-stroke versus four-stroke, and whether the engine is rich burn or lean burn. We applied NSPS reduction for lean burn, rich burn and "combined" engines using Equation 2 and information listed in Table 2. For the ptnonipm sector, RICE NSPS control factors supplied by MARAMA were used within the MARAMA region. Table 3 lists the nonpoint and point source SCCs where RICE NSPS controls were applied for the 2016v1 platform. Table 4 shows the reduction in emissions in the ptnonipm sector after the application of the RICE NSPS CONTROL packet for both future years 2023 and 2028. The values in Table 4 include emissions both inside and outside the MARAMA region.

Table 3. Point source SCCs and Engine Type in 2016v1 modeling platform where RICE NSPS controls applied.

SCC	Lean, Rich, or Combined	SCCDESC
20200202	Combined	Internal Combustion Engines; Industrial; Natural Gas; Reciprocating
20200253	Rich	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Rich Burn
20200254	Lean	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Lean Burn
20200256	Lean	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Clean Burn
20300201	Combined	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Reciprocating
2102006000	Combined	Stationary Source Fuel Combustion; Industrial; Natural Gas; Total: Boilers and IC Engines
2102006002	Combined	Stationary Source Fuel Combustion; Industrial; Natural Gas; All IC Engine Types
2103006000	Combined	Stationary Source Fuel Combustion; Commercial/Institutional; Natural Gas; Total: Boilers and IC Engines

Table 4. Emissions reductions (tons) after the application of the RICE NSPS CONTROL packet for the ptnonipm sector in 2023 and 2028.

year	poll	2016v1 (tons)	emissions reductions (tons)	% change
2023	CO	1,446,353	-2,756	-0.2%
2023	NOX	952,181	-3,400	-0.4%
2023	VOC	774,289	-2	0.0%
2028	CO	1,446,353	-3,295	-0.2%
2028	NOX	952,181	-4,232	-0.4%
2028	VOC	774,289	-3	0.0%

Natural Gas Turbines NO_X NSPS

Natural Gas Turbines NSPS controls were generated based on examination of emission limits for stationary combustion turbines that are not in the power sector. In 2006, the EPA promulgated standards of performance for new stationary combustion turbines in 40 CFR part 60, subpart KKKK. The standards reflect changes in NOx emission control technologies and turbine design since standards for these units were originally promulgated in 40 CFR part 60, subpart GG. The 2006 NSPSs affecting 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 5 compares the 2006 NSPS emission limits with the NOx RACT regulations in selected states within the NOx SIP Call region. The map showing the states and partial-states in the NOx SIP Call Program can be found at: http://www3.epa.gov/airmarkets/progress/reports/program_basics.html. 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 5. Stationary gas turbines NSPS analysis and resulting emission rates used to compute controls

NOx Emission Limits for New Stationary Combustion Turbines				
Firing Natural Gas	<50 MMBTU/hr	50-850 MMBTU/hr	>850 MMBTU/hr	
Federal NSPS	100	25	15	ppm
State RACT Regulations	5-100 MMBTU/hr	100-250 MMBTU/hr	>250 MMBTU/hr	
Connecticut	225	75	75	ppm

Delaware	42	42	42	ppm
Massachusetts	65*	65	65	ppm
New Jersey	50*	50	50	ppm
New York	50	50	50	ppm
New Hampshire	55	55	55	ppm
* Only applies to 25-100 MMBTU/hr				
Notes: The above state RACT table is from a 2001 analysis. The current NY State regulations have the same emission limits.				
New source emission rate (Fn)			NO_X ratio (Fn)	Control (%)
NOx SIP Call states plus CA	= 25 / 42 =		0.595	40.5%
Other states	= 25 / 105 =		0.238	76.2%

For control factor development, the existing source emission ratio was set to 1.0 for combustion turbines. The new source emission ratio for the NOx SIP Call states and California is the ratio of state NOx emission limit to the Federal NSPS. A complicating factor in the above is the lack of size information in the stationary source SCCs. Plus, the size classifications in the NSPS do not match the size differentiation used in state air emission regulations. We accepted a simplifying assumption that most industrial applications of combustion turbines are in the 100-250 MMBtu/hr size range and computed the new source emission rates as the NSPS emission limit for 50-850 MMBtu/hr units divided by the state emission limits. We used a conservative new source emission ratio by using the lowest state emission limit of 42 ppmv (Delaware). This yields a new source emission ratio of 25/42, or 0.595 (40.5 percent reduction) for states with existing combustion turbine emission limits. States without existing turbine 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* as a function of the year-specific projection factor. Also, Natural Gas Turbines control factors supplied by MARAMA were used within the MARAMA region.

Table 6 lists the point source SCCs where Natural Gas Turbines NSPS controls were applied for the 2016v1 platform. Table 7 shows the reduction in NOx emissions after the application of the Natural Gas Turbines NSPS CONTROL packet for both future years 2023 and 2028. The values in Table 7 include emissions both inside and outside the MARAMA region.

Table 6. Point source SCCs in 2016v1 modeling platform where Natural Gas Turbines NSPS controls applied.

SCC	SCC description
20200201	Internal Combustion Engines; Industrial; Natural Gas; Turbine
20200203	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Cogeneration
20200209	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Exhaust
20200701	Internal Combustion Engines; Industrial; Process Gas; Turbine

20200714	Internal Combustion Engines; Industrial; Process Gas; Turbine: Exhaust
20300202	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine
20300203	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine: Cogeneration

Table 7. Emissions reductions (tons) after the application of the Natural Gas Turbines NSPS CONTROL packet for the ptnonipm sector in 2023 and 2028.

year	poll	2016v1 (tons)	emissions reduction (tons)	% change
2023	NOX	952,181	-2,531	-0.3%
2028	NOX	952,181	-3,346	-0.4%

Process Heaters NO_X NSPS

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 2016, it is assumed that process heaters have not been subject to regional control programs like the NOx SIP Call, so most of the emission controls put in-place at refineries and chemical plants have resulted from RACT regulations that were implemented as part of SIPs to achieve ozone NAAQS in specific areas, and refinery consent decrees. The boiler/process heater NSPS established NOx emission limits for new and modified process heaters. These emission limits are displayed in Table 8.

Table 8. Process Heaters NSPS analysis and 2016v1 new emission rates used to estimate controls

NO_X emission rate Existing (Fe)	**Fraction at this rate**		**Average**
PPMV	**Natural Draft**	**Forced Draft**	
80	0.4	0	
100	0.4	0.5	
150	0.15	0.35	
200	0.05	0.1	

240	0	0.05	
Cumulative, weighted: Fe	104.5	134.5	119.5
NSPS Standard	40	60	
New Source NO_X ratio (Fn)	0.383	0.446	**0.414**
NSPS Control (%)	61.7	55.4	58.6

For computations, the existing source emission ratio (Fe) was set to 1.0. The computed (average) NO_x emission factor ratio for new sources (Fn) is 0.41 (58.6 percent control). The retirement rate is the inverse of the expected unit lifetime. There is limited information in the literature about process heater lifetimes. This information was reviewed at the time that the Western Regional Air Partnership (WRAP) developed its initial regional haze program emission projections, and energy technology models used a 20-year lifetime for most refinery equipment. However, it was noted that in practice, heaters would probably have a lifetime that was on the order of 50 percent above that estimate. Therefore, a 30-year lifetime was used to estimate the effects of process heater growth and retirement. This yields a 3.3 percent retirement rate. This control was then plugged into *Equation 2* as a function of the year-specific projection factor. Table 9 lists the point source SCCs where Process Heaters NSPS controls were applied for the 2016v1 platform. Table 10 shows the reduction in NOx emissions after the application of the Process Heaters NSPS CONTROL packet for both future years 2023 and 2028.

Table 9. Point source SCCs in 2016v1 modeling platform where Process Heaters NSPS controls applied.

scc	sccdesc
30190003	Industrial Processes; Chemical Manufacturing; Fuel Fired Equipment; Process Heater: Natural Gas
30190004	Industrial Processes; Chemical Manufacturing; Fuel Fired Equipment; Process Heater: Process Gas
30590002	Industrial Processes; Mineral Products; Fuel Fired Equipment; Residual Oil: Process Heaters
30590003	Industrial Processes; Mineral Products; Fuel Fired Equipment; Natural Gas: Process Heaters
30600101	Industrial Processes; Petroleum Industry; Process Heaters; Oil-fired
30600102	Industrial Processes; Petroleum Industry; Process Heaters; Gas-fired
30600103	Industrial Processes; Petroleum Industry; Process Heaters; Oil
30600104	Industrial Processes; Petroleum Industry; Process Heaters; Gas-fired
30600105	Industrial Processes; Petroleum Industry; Process Heaters; Natural Gas-fired
30600106	Industrial Processes; Petroleum Industry; Process Heaters; Process Gas-fired
30600107	Industrial Processes; Petroleum Industry; Process Heaters; Liquified Petroleum Gas (LPG)
30600199	Industrial Processes; Petroleum Industry; Process Heaters; Other Not Classified
30990003	Industrial Processes; Fabricated Metal Products; Fuel Fired Equipment; Natural Gas: Process Heaters
31000401	Industrial Processes; Oil and Gas Production; Process Heaters; Distillate Oil (No. 2)

scc	sccdesc
31000402	Industrial Processes; Oil and Gas Production; Process Heaters; Residual Oil
31000403	Industrial Processes; Oil and Gas Production; Process Heaters; Crude Oil
31000404	Industrial Processes; Oil and Gas Production; Process Heaters; Natural Gas
31000405	Industrial Processes; Oil and Gas Production; Process Heaters; Process Gas
31000406	Industrial Processes; Oil and Gas Production; Process Heaters; Propane/Butane
31000413	Industrial Processes; Oil and Gas Production; Process Heaters; Crude Oil: Steam Generators
31000414	Industrial Processes; Oil and Gas Production; Process Heaters; Natural Gas: Steam Generators
31000415	Industrial Processes; Oil and Gas Production; Process Heaters; Process Gas: Steam Generators
39900501	Industrial Processes; Miscellaneous Manufacturing Industries; Process Heater/Furnace; Distillate Oil
39900601	Industrial Processes; Miscellaneous Manufacturing Industries; Process Heater/Furnace; Natural Gas
39990003	Industrial Processes; Miscellaneous Manufacturing Industries; Miscellaneous Manufacturing Industries; Natural Gas: Process Heaters

Table 10. Emissions reductions (tons) after the application of the Process Heaters NSPS CONTROL packet for the ptnonipm sector in 2023 and 2028.

year	poll	2016v1 (tons)	emissions reductions (tons)	% change
2023	NOX	952,181	-9,511	-1.0%
2028	NOX	952,181	-12,692	-1.3%

CISWI

On March 21, 2011, the EPA promulgated the revised NSPS and emission guidelines for Commercial and Industrial Solid Waste Incineration (CISWI) units. This was a response to the voluntary remand that was granted in 2001 and the vacatur and remand of the CISWI definition rule in 2007. In addition, the standards redevelopment included the 5-year technology review of the new source performance standards and emission guidelines required under Section 129 of the Clean Air Act. The history of the CISWI implementation is documented here: https://www.epa.gov/stationary-sources-air-pollution/commercial-and-industrial-solid-waste-incineration-units-ciswi-new. Baseline and CISWI rule impacts associated with the CISWI rule are documented here: https://www.regulations.gov/document?D=EPA-HQ-OAR-2003-0119-2559. The EPA mapped the units from the CISWI baseline and controlled dataset to the 2014 NEI inventory and computed percent reductions such that our future year emissions matched the CISWI controlled dataset values. Table 11 summarizes the total impact of CISWI controls for 2023 and 2028. Note that this rule applies to specific units in 11 states: Alaska, Arkansas, Illinois, Iowa, Louisiana, Maine, Oklahoma, Oregon, Pennsylvania, Tennessee, and Texas for CO, SO_2, and NO_X.

Table 11. Summary of CISWI rule impacts on ptnonipm emissions for 2023 and 2028.

year	poll	2016v1 (tons)	emissions reductions (tons)	% change
2023	CO	1,446,353	-2,745	-0.2%
2023	NOX	952,181	-1,711	-0.2%
2023	SO2	658,204	-1,807	-0.3%
2028	CO	1,446,353	-2,937	-0.2%
2028	NOX	952,181	-1,722	-0.2%
2028	SO2	658,204	-1,933	-0.3%

Petroleum Refineries: NSPS Subpart JA

On June 24, 2008, EPA issued final amendments to the Standards of Performance for Petroleum Refineries. This action also promulgated separate standards of performance for new, modified, or reconstructed process units after May 14, 2007 at petroleum refineries. The final standards for new process units included emissions limitations and work practice standards for fluid catalytic cracking units, fluid coking units, delayed coking units, fuel gas combustion devices, and sulfur recovery plants. In 2012, EPA finalized the rule after some amendments and technical corrections. See https://www.epa.gov/stationary-sources-air-pollution/petroleumrefineries-new-source-performance-standards-nsps-40-cfr for more details on NSPS – 40 CFR 60 Subpart Ja. These NSPS controls were applied to petroleum refineries in the ptnonipm sector for years 2023 and 2028. Units impacted by this rule were identified in the 2016v1 inventory. For delayed coking units, an 84% control efficiency was applied and for storage tanks, a 49% control efficiency was applied. The analysis of applicable units was completed prior to the 2014v2 NEI and the 2016v1 platform. Therefore, to ensure that a control was not applied to a unit that was already in compliance with this rule, we compared emissions from the 2016v1 inventory and the 2011en inventory (the time period of the original analysis). Any unit that demonstrated a 55+% reduction in VOC emissions from 2011en to 2016v1 would be considered compliant with the rule and therefore not subject to this control. Table 12 below reflects the impacts of these NSPS controls on the ptnonipm sector. This control is applied to all pollutants; Table 12 summarizes reductions for the years 2023 and 2028 for NO_X, SO_2, and VOC.

Table 12. Summary of NSPS Subpart JA rule impacts on ptnonipm emissions for 2023 and 2028.

year	poll	2016v1 (tons)	emissions reductions (tons)	% change
2023	NOX	952,181	-1	0.0%
2023	SO2	658,204	-3	0.0%
2023	VOC	774,289	-5,269	-0.7%
2028	NOX	952,181	-1	0.0%
2028	SO2	658,204	-3	0.0%
2028	VOC	774,289	-5,233	-0.7%

ICI Boilers – North Carolina

The Industrial/Commercial/Institutional Boilers and Process Heaters MACT Rule, hereafter simply referred to as the "Boiler MACT," was promulgated on January 31, 2013, based on reconsideration. Background information on the Boiler MACT can be found at: https://www.epa.gov/stationary-sources-air-pollution/cleanair-act-standards-and-guidelines-energy-engines-and. The Boiler MACT promulgates national emission standards for the control of HAPs (NESHAP) for new and existing industrial, commercial, and institutional (ICI) boilers and process heaters at major sources of HAPs. The expected cobenefit for CAPs at these facilities is significant and greatest for SO2 with lesser impacts for direct PM, CO and VOC. This control addresses only the expected cobenefits to existing ICI boilers in the State of North Carolina. All other states previously considered for this rule are assumed to be in compliance with the rule and therefore the emissions need no further estimated controls applied. The control factors applied here were provided by North Carolina.

Fuel Sulfur Rules

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 Hampshire, New Jersey, 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. The control packet representing these controls was updated by MARAMA for version 1 platform.

A summary of the sulfur rules by state, with emissions reductions is provided in Table 13. This table reflects the impacts of the MARAMA packet only, as these reductions are not estimated in non-MARAMA states. Most of these reductions occur in the nonpt sector; a small amount of reductions occur in the ptnonipm sector, and a negligible amount of reductions occur in the pt_oilgas sector.

Table 13. Summary of fuel sulfur rule impacts on ptnonipm SO2 emissions for 2023 and 2028.

year	poll	2016v1 (tons)	emissions reductions (tons)	% change
2023	SO2	658,204	-1,183	-0.2%
2028	SO2	658,204	-1,241	-0.2%

Arizona Regional Haze Controls

U.S. EPA Region 9 provided regional haze FIP controls for a few industrial facilities. Information on these controls are available in the Federal Register (EPA-R09-OAR-2013-0588; FRL-9912-97-OAR) at http://www.federalregister.com. These non-EGU controls have implementation dates between September 2016 and December 2018.

Data from comments on previous platforms and recent comments

All remaining ptnonipm controls are discussed in this section. For point sources, controls include data from the 2018 NODA process as well as a concatenation of all remaining controls not already discussed.

Consent Decrees

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

State Comments

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

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

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

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

The District of Columbia provided a control packet to be applied to three ptnonipm facilities in all version 1 platform projections.

6. Emissions Processing Requirements

Ptnonipm emissions were processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE[1]) modeling system. As with all point source sectors, this is typically handled with two separate scripts, or "jobs": one which processes time-independent, or "onetime", programs (Smkinven, Spcmat, Grdmat, Smkreport, Elevpoint), and one which processes time-dependent programs (Temporal, Smkmerge).

The ptnonipm sector was processed through SMOKE using a PELVCONFIG file that classifies a portion of the sector as "elevated". The criterion for elevated sources is a plume rise of 20 meters or greater, according to the Briggs algorithm[2]. A value of 20 meters was chosen because this is a typical upper bound of Layer 1 in air quality modeling.

Elevated sources are output to an inline point source file for input to CMAQ, and remaining sources are output to a 2-D gridded emissions file. Therefore, one must sum both files together to capture emissions from all ptnonipm sources. The 2-D gridded emissions from ptnonipm must be included in the 2-D sector merge. The reason we do not classify all sources as elevated in pt_oilgas and ptnonipm, as we do with cmv_c3 and othpt, is to limit the size of the inline point source files from these sectors.

[1] http://www.smoke-model.org/index.cfm
[2] https://www.cmascenter.org/smoke/documentation/4.5/html/ch06s03.html#sect_programs_elevpoint_briggs

7. Emissions Summaries

National and state totals by pollutant for the 2016v1 platform cases are provided here. Plots and maps are available online through the LADCO website[3] and the Intermountain West Data Warehouse[4]. The case descriptions are as follows:

2014fd = 2014NEIv2 and 2014 NATA

2016fe = 2016 alpha platform (grown from 2014NEIv2)

2016ff, 2023ff, 2028ff = 2016 beta platform

2016fh, 2023fh, 2028fh = 2016 v1 platform

Table 14. Comparison of national total annual CAPS ptnonipm emissions (tons/yr)

Pollutant	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
CO	1,635,665	1,430,994	1,421,976	1,446,353	1,435,104	1,456,054	1,448,163	1,468,933
NH3	64,114	61,680	63,862	64,019	64,204	64,030	64,321	64,280
NOX	1,069,289	983,207	945,730	952,181	946,040	941,016	950,037	946,003
PM10	435,801	402,880	395,865	398,927	399,371	402,237	401,411	404,550
PM2.5	279,346	258,437	252,911	255,537	255,953	258,309	257,620	260,177
SO2	917,032	705,220	662,403	658,204	619,130	575,855	621,863	578,595
VOC	783,289	767,597	771,363	774,289	766,257	775,831	766,986	776,958

Table 15. Comparison of state total annual NOx ptnonipm emissions (tons/yr)

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Alabama	48,513	44,852	44,862	44,873	45,662	44,868	46,240	45,361
Alaska	17,266	15,956	7,720	7,720	7,794	7,670	7,819	7,699
Arizona	5,798	5,439	5,156	5,105	3,791	3,738	3,812	3,748
Arkansas	17,547	15,009	15,208	15,218	15,643	15,905	15,968	16,129
California	36,018	35,564	38,070	37,030	38,156	36,774	37,860	36,423
Colorado	13,861	13,755	13,832	13,843	14,151	14,183	14,302	14,305
Connecticut	2,130	745	745	745	763	791	781	811
Delaware	2,243	1,874	1,874	1,870	2,012	1,998	1,968	2,041
District of Columbia	448	451	456	365	472	390	484	396
Florida	25,635	23,562	23,360	23,069	23,571	23,224	23,967	23,633
Georgia	36,983	28,623	28,041	30,708	28,804	30,297	29,205	30,746
Hawaii	22,812	20,233	2,708	2,711	2,663	2,791	2,678	2,805
Idaho	6,834	5,698	5,750	5,751	6,305	5,955	6,632	6,276
Illinois	34,962	31,438	32,053	32,354	31,670	31,743	31,501	31,583
Indiana	42,779	39,360	39,817	39,900	40,437	40,036	40,789	40,264

[3] https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/
[4] http://views.cira.colostate.edu/iwdw/eibrowser2016

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Iowa	17,448	15,209	14,814	14,896	14,056	13,358	14,292	13,394
Kansas	11,353	10,959	11,091	11,128	11,481	11,270	11,474	11,238
Kentucky	19,397	19,953	19,700	19,696	19,995	19,756	20,162	19,883
Louisiana	69,819	68,022	68,367	68,297	70,005	67,433	69,748	68,027
Maine	7,421	5,076	5,076	5,041	5,171	4,727	5,330	4,704
Maryland	9,903	7,737	7,875	7,941	7,890	7,661	7,879	7,556
Massachusetts	5,439	4,627	4,494	11,361	3,976	11,474	4,001	11,536
Michigan	40,087	46,711	43,478	43,548	41,154	41,030	41,277	41,171
Minnesota	42,190	32,685	33,084	33,093	27,818	27,105	28,152	27,364
Mississippi	13,326	13,163	13,127	13,122	13,343	12,957	13,452	13,044
Missouri	24,676	21,158	20,732	20,693	20,706	20,726	20,802	20,761
Montana	6,288	5,909	5,294	5,155	5,365	5,045	5,414	5,078
Nebraska	7,890	7,431	7,289	7,249	7,487	7,235	7,589	7,245
Nevada	5,148	5,060	5,007	5,007	5,046	5,078	5,061	5,082
New Hampshire	642	521	521	453	515	435	506	452
New Jersey	5,578	4,953	4,872	4,615	4,911	4,619	4,920	4,639
New Mexico	2,660	2,633	8,915	8,932	9,380	10,032	9,318	10,521
New York	18,726	15,896	15,122	14,670	14,992	14,588	15,087	14,651
North Carolina	28,729	27,597	28,175	28,162	26,055	27,830	26,433	28,505
North Dakota	4,117	3,837	3,530	3,634	3,828	3,554	3,922	3,601
Ohio	42,562	37,382	36,752	37,282	37,171	36,227	37,234	36,277
Oklahoma	21,887	19,813	34,555	34,589	33,596	34,568	32,498	32,913
Oregon	11,695	11,727	10,129	9,853	10,223	10,029	10,434	10,226
Pennsylvania	39,251	36,011	35,446	34,105	35,618	42,538	35,633	42,750
Rhode Island	866	869	869	827	787	831	788	841
South Carolina	23,805	25,369	22,732	22,735	23,305	22,863	23,749	23,323
South Dakota	2,589	2,588	2,624	2,651	2,659	2,633	2,680	2,609
Tennessee	29,478	27,684	27,620	27,592	29,188	26,639	30,005	27,331
Texas	99,451	94,008	95,115	94,988	96,030	93,610	94,860	93,126
Utah	12,011	11,784	11,931	11,933	12,693	12,783	12,729	12,723
Vermont	157	159	159	106	126	108	131	114
Virginia	29,705	19,611	19,737	19,733	20,024	14,721	20,182	15,427
Washington	16,023	14,781	15,837	15,910	15,485	15,136	15,352	15,084
West Virginia	9,088	8,327	8,038	8,001	8,547	8,066	8,745	8,096
Wisconsin	29,571	31,534	22,972	22,921	22,785	22,594	22,816	22,625
Wyoming	20,230	19,460	19,072	19,075	20,818	19,525	21,447	19,993
Puerto Rico	26,047	20,197	1,719	1,719	1,686	1,659	1,685	1,657
Tribal Data	209	205	205	205	226	207	246	219

Table 16. Comparison of state total annual SO2 ptnonipm emissions (tons/yr)

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Alabama	43,663	39,046	39,165	39,170	39,682	39,152	40,100	39,508
Alaska	3,053	3,137	1,406	1,406	1,493	1,383	1,525	1,415
Arizona	24,013	24,264	24,265	24,263	6,405	6,403	6,405	6,403

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Arkansas	9,493	7,766	7,769	7,788	7,529	10,862	7,749	10,676
California	9,947	11,099	11,062	11,031	11,193	11,075	11,095	11,016
Colorado	2,916	2,816	2,820	2,817	2,843	2,835	2,859	2,852
Connecticut	177	94	94	94	90	91	91	93
Delaware	840	745	745	745	710	717	694	733
District of Columbia	49	27	27	21	32	17	32	17
Florida	31,297	28,704	28,706	28,436	28,779	28,443	28,867	28,609
Georgia	26,641	17,692	17,498	19,663	17,271	18,445	17,148	18,828
Hawaii	19,207	18,912	902	911	910	889	910	881
Idaho	4,653	2,473	2,475	2,473	2,553	2,417	2,605	2,462
Illinois	35,447	24,479	24,499	24,491	21,561	19,508	21,704	19,634
Indiana	48,399	38,892	38,898	38,911	39,244	38,596	39,919	38,962
Iowa	24,231	6,563	6,566	6,616	6,862	6,445	6,988	6,489
Kansas	4,727	3,788	3,795	3,793	3,812	3,795	3,814	3,793
Kentucky	15,804	15,793	15,235	15,238	15,643	15,026	15,883	15,171
Louisiana	85,084	70,086	70,093	70,086	68,453	57,474	67,749	56,883
Maine	3,060	1,560	1,560	1,549	1,166	1,127	1,204	1,148
Maryland	18,438	10,042	10,044	10,043	9,806	9,334	9,457	9,033
Massachusetts	1,812	1,798	1,131	4,115	791	3,892	789	3,912
Michigan	21,171	12,980	12,968	12,918	12,821	12,881	12,935	12,925
Minnesota	12,584	9,231	9,238	9,236	9,607	8,995	9,782	9,142
Mississippi	12,336	10,863	10,865	10,920	11,402	10,762	11,688	10,993
Missouri	32,626	12,866	12,871	12,921	13,652	11,977	13,679	11,997
Montana	3,330	2,750	2,751	2,749	2,785	2,742	2,799	2,753
Nebraska	2,534	1,840	1,844	1,840	1,887	1,829	1,911	1,833
Nevada	995	1,120	1,121	1,120	1,144	1,127	1,145	1,127
New Hampshire	733	672	672	486	216	182	212	192
New Jersey	1,008	898	895	803	856	813	852	823
New Mexico	290	147	7,638	7,663	7,644	7,718	7,645	7,719
New York	23,904	9,425	9,427	7,925	9,455	7,646	9,501	7,658
North Carolina	20,713	21,175	21,180	21,175	12,844	13,875	12,918	13,896
North Dakota	2,409	2,150	2,151	2,214	2,460	1,958	2,523	2,011
Ohio	66,805	42,761	40,944	40,947	38,177	30,949	38,301	31,128
Oklahoma	25,067	22,992	23,380	23,451	23,342	23,281	23,270	23,200
Oregon	2,017	1,933	1,447	1,419	1,443	1,428	1,457	1,438
Pennsylvania	25,532	23,285	23,117	16,094	23,494	16,493	23,521	16,621
Rhode Island	268	239	239	312	122	160	121	170
South Carolina	17,372	12,700	11,951	11,948	12,063	11,656	12,193	11,912
South Dakota	624	624	624	622	601	582	606	580
Tennessee	31,422	24,693	24,699	24,702	14,109	10,745	14,457	10,926
Texas	61,338	60,077	60,107	59,701	61,221	59,214	61,185	59,532
Utah	2,279	2,182	2,185	2,182	2,409	2,148	2,382	2,127
Vermont	174	175	175	42	26	12	27	13
Virginia	34,187	21,878	22,135	22,142	18,927	11,234	18,931	11,787
Washington	11,159	7,732	7,732	7,726	7,673	7,537	7,678	7,553

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
West Virginia	7,873	8,101	7,662	7,661	8,208	7,286	8,500	7,250
Wisconsin	44,989	22,267	20,489	20,484	18,959	19,805	18,479	19,340
Wyoming	11,532	11,749	11,751	11,750	13,505	11,776	14,324	12,312
Puerto Rico	26,783	25,913	1,361	1,361	1,219	1,089	1,218	1,089
Tribal Data	29	28	28	28	32	29	35	31

Table 17. Comparison of state total annual VOC ptnonipm emissions (tons/yr)

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Alabama	27,900	27,732	27,556	27,566	27,535	27,475	27,579	27,448
Alaska	1,216	1,243	929	929	875	873	873	865
Arizona	2,530	2,540	2,522	2,519	2,523	2,509	2,525	2,498
Arkansas	22,647	18,722	18,734	18,757	18,774	18,917	18,805	18,907
California	32,435	33,874	33,976	33,936	33,560	33,489	33,532	33,402
Colorado	21,299	21,403	21,407	21,414	21,418	21,379	21,429	21,322
Connecticut	811	666	666	666	667	698	669	711
Delaware	933	850	850	849	826	820	826	819
District of Columbia	42	68	68	55	69	56	70	57
Florida	22,086	22,991	22,971	22,959	23,123	22,972	23,313	23,039
Georgia	27,226	26,855	26,294	26,539	26,356	26,514	26,401	26,511
Hawaii	3,275	3,063	2,900	2,909	2,900	2,876	2,924	2,852
Idaho	1,472	1,507	1,510	1,510	1,526	1,510	1,539	1,511
Illinois	39,351	36,631	36,665	36,761	36,004	36,932	36,007	36,742
Indiana	30,163	30,940	30,964	31,045	30,998	31,607	31,012	31,429
Iowa	21,218	19,300	19,264	19,646	19,258	20,792	19,273	20,565
Kansas	12,781	12,407	12,414	12,439	12,132	12,058	12,143	12,001
Kentucky	45,361	44,618	44,006	43,980	43,945	44,091	43,949	44,061
Louisiana	41,713	43,988	44,008	44,003	43,675	43,424	43,679	43,279
Maine	2,745	2,365	2,365	2,365	2,371	2,213	2,376	2,149
Maryland	2,004	1,832	1,842	1,846	1,845	1,832	1,847	1,827
Massachusetts	2,682	2,628	2,636	4,843	2,631	4,763	2,634	4,744
Michigan	22,258	22,726	22,667	22,677	22,573	22,560	22,563	22,508
Minnesota	19,156	18,221	18,430	18,425	18,313	18,673	18,319	18,554
Mississippi	25,282	22,896	22,546	22,635	22,791	22,841	22,942	22,851
Missouri	12,943	13,365	13,336	13,418	13,341	14,475	13,349	14,366
Montana	3,014	3,271	3,234	3,225	3,135	3,112	3,136	3,105
Nebraska	4,494	5,001	4,991	4,992	5,016	4,953	5,026	4,907
Nevada	1,507	1,551	1,547	1,547	1,545	1,555	1,547	1,555
New Hampshire	227	212	212	216	212	226	213	227
New Jersey	6,995	6,747	6,744	6,615	6,551	6,386	6,553	6,429
New Mexico	1,380	1,566	3,380	3,408	3,498	3,634	3,513	3,696
New York	6,934	6,463	6,443	6,258	6,471	6,395	6,481	6,451
North Carolina	38,618	38,231	38,265	38,264	36,793	41,787	36,813	44,152
North Dakota	2,672	2,026	2,007	2,069	2,028	2,303	2,041	2,281
Ohio	28,350	29,589	28,714	28,755	28,439	28,415	28,448	28,342

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Oklahoma	14,791	16,756	21,632	21,707	21,690	22,059	21,619	21,806
Oregon	9,539	9,132	8,880	8,880	8,938	8,901	8,963	8,909
Pennsylvania	20,360	20,254	20,201	20,138	20,157	19,981	20,157	19,986
Rhode Island	971	933	933	928	928	977	929	982
South Carolina	24,182	24,215	24,084	24,085	24,033	23,999	24,069	24,024
South Dakota	3,296	3,247	3,249	3,247	3,268	3,217	3,278	3,182
Tennessee	36,238	35,307	35,299	35,307	35,227	35,142	35,246	35,137
Texas	69,976	66,655	66,699	66,729	65,472	65,171	65,483	64,894
Utah	2,962	3,394	3,402	3,402	3,311	3,312	3,317	3,292
Vermont	287	289	289	283	289	253	290	240
Virginia	16,431	16,204	16,422	16,336	16,383	15,092	16,399	15,832
Washington	10,879	8,774	9,374	9,379	9,041	8,943	9,043	8,833
West Virginia	4,807	4,419	4,580	4,578	4,596	4,570	4,601	4,566
Wisconsin	20,961	21,830	21,394	21,391	21,410	21,373	21,424	21,361
Wyoming	10,834	6,932	6,915	6,915	6,846	6,781	6,872	6,802
Puerto Rico	352	469	247	247	245	244	245	244
Tribal Data	700	700	700	700	702	700	704	702

Figure 1. Annual Gridded 2016 ptnonipm NOx emissions

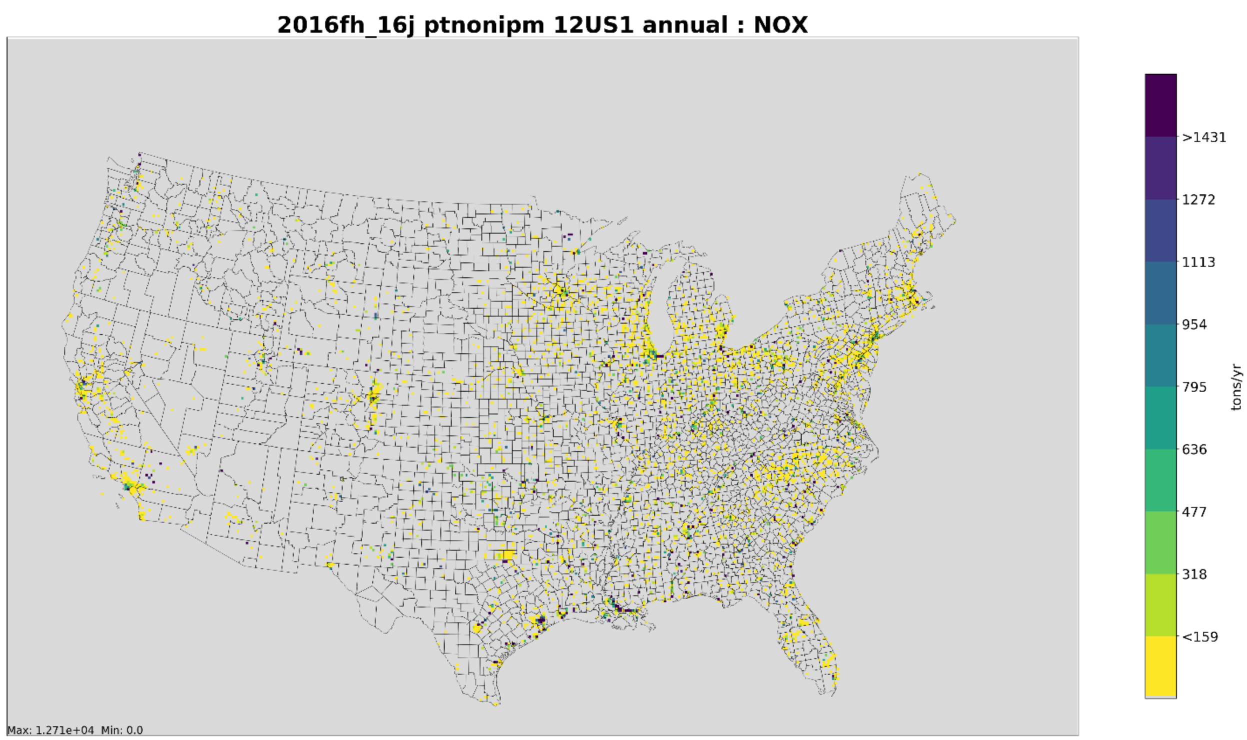


Figure 2. Annual Gridded 2016 ptnonipm SO2 emissions

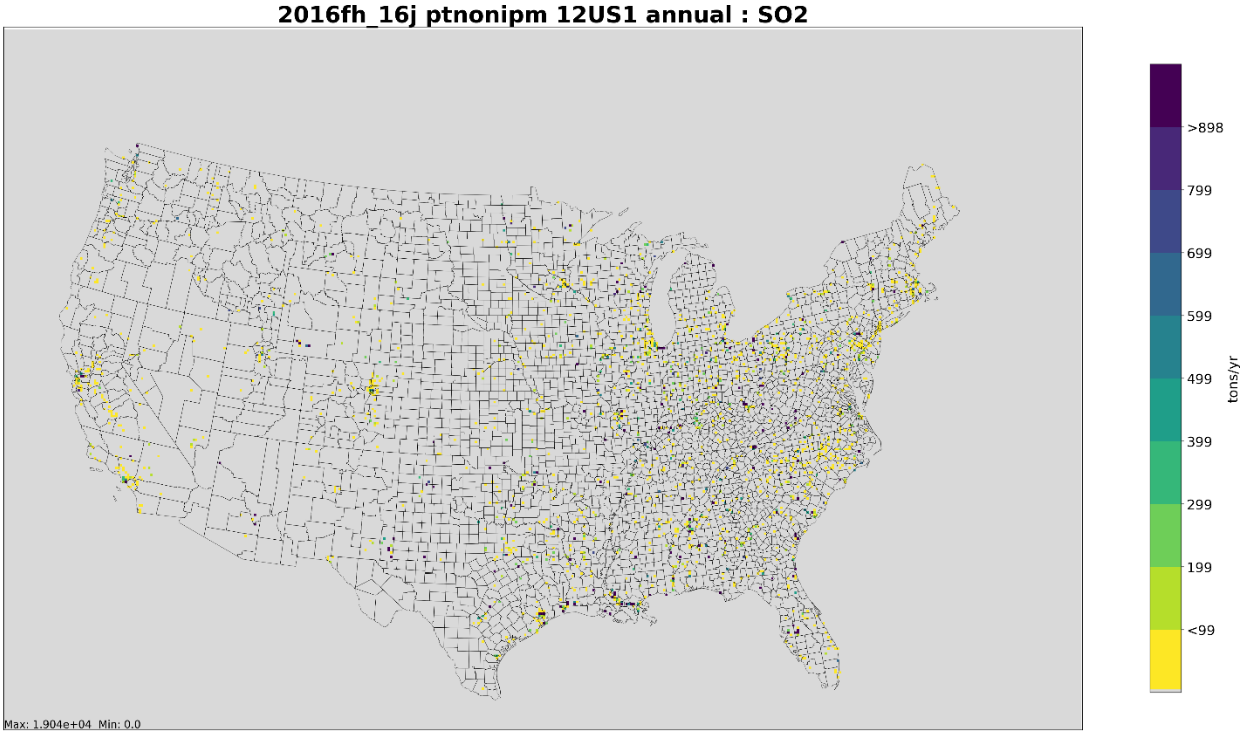


Figure 3. Annual County-total 2016 ptnonipm NOx emissions

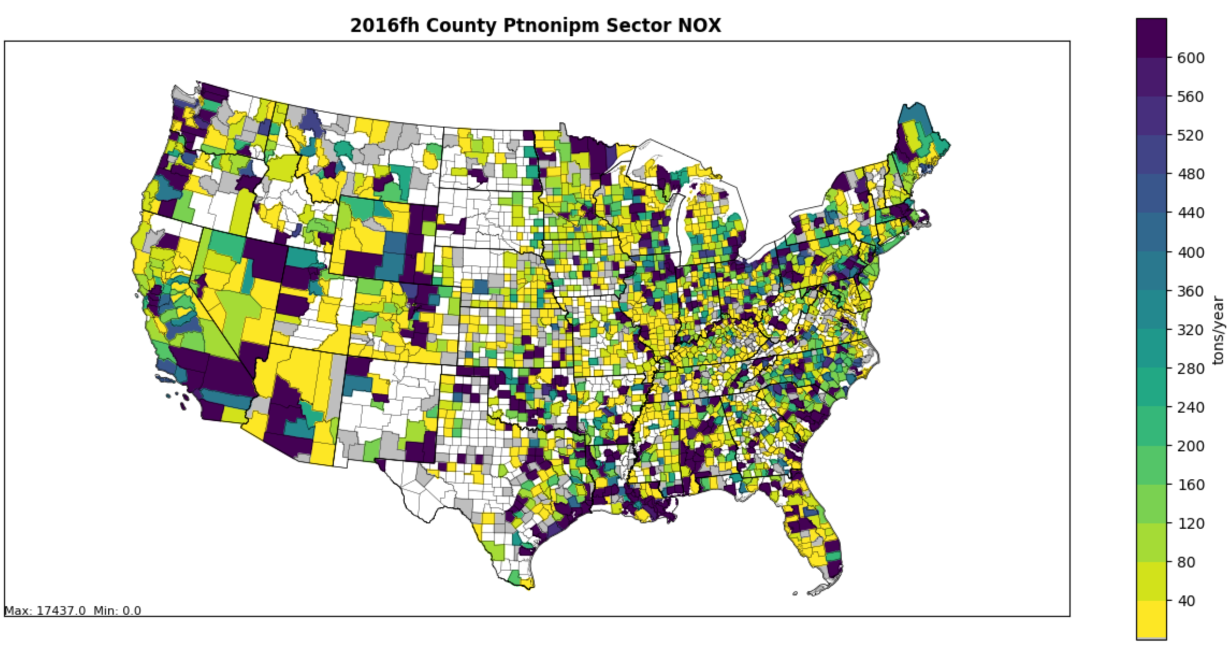


Figure 4. Annual County-total 2016 ptnonipm SO2 emissions