

September 17, 2019

SPECIFICATION SHEET: NP_OILGAS

Description: Nonpoint oil and gas (np_oilgas) emissions, for simulating 2016 U.S. air quality

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1. EXECUTIVE SUMMARY

The np_oilgas sector consists of non-point (area) source oil and gas emissions. All emissions from this sector are derived from the Oil and Gas Tool, except in California, Colorado, Oklahoma, and Pennsylvania, which use alternative datasets. This sector employs special monthly temporal profiles and spatial allocation specific to oil and gas sources. Base year inventories were processed with the Sparse Matrix Operating Kernel Emissions (SMOKE) modeling system version 4.6. SMOKE creates emissions in a format that can be input into air quality models. National and state-level emission summaries for key pollutants are provided.

2. INTRODUCTION

Nonpoint source emissions from the oil and gas exploration and production sector have gained interest in recent years in the United States as drilling technology has allowed development of unconventional oil and gas plays in areas where there was previously no activity, or where activity had subsided after depletion of the conventional reserves. For example, the areas in and around the Barnett, Haynesville, and Eagle Ford Shales in Texas; the Marcellus Shale in Ohio, Pennsylvania, and West Virginia; and the Bakken Shale/Williston Basin in North Dakota and Montana have all experienced a rapid expansion in activity over the last twelve years. These are referred to as “unconventional” oil and gas plays as the resource must be stimulated through high-pressure, high-volume hydraulic fracturing to release the oil and gas trapped in the source formation (such as shale or tight sands). In EPA’s Oil and Gas Tool, these types of wells are assumed to have been hydraulically fractured when completed, and emissions from the hydraulic fracturing pump engines are included as a discrete source type.

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

This document details the approach and data sources to be used for developing 2016 emissions for the nonpoint oil and gas (np_oilgas) sector, which consists of oil and gas exploration and production sources, both onshore and offshore (state-owned only). In 2016 beta platform, these emissions are mostly based on the Oil and Gas Tool, with other data sources in some states. Because of the growing importance of these emissions, special consideration is given to the speciation, allocation, and monthly temporalization of nonpoint oil and gas emissions, instead of relying on older, more generalized profiles.

A list of all Source Category codes (SCCs) in the np_oilgas sector is provided in Table 1. The table also specifies if SCC is covered by the EPA Oil and Gas Tool or if it was state-submitted. Table 1 also has a column indicating if the SCC is an EXPLORATION or PRODUCTION-related SCC.

Table 1. SCC in the np_oilgas sector for 2016beta inventory

SCC	TOOL OR STATE SCC	PRODUCTION OR EXPLORATION SCC	SCCDESC
2310000000	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Total: All Processes
2310000220	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Drill Rigs
2310000230	STATE	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Workover Rigs
2310000330	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Artificial Lift
2310000550	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Produced Water
2310000660	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; All Processes; Hydraulic Fracturing Engines
2310010100	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Crude Petroleum; Oil Well Heaters
2310010200	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Crude Petroleum; Oil Well Tanks - Flashing & Standing/Working/Breathing
2310010300	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Crude Petroleum; Oil Well Pneumatic Devices
2310011000	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Production; Total: All Processes
2310011201	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Production; Tank Truck/Railcar Loading: Crude Oil
2310011500	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: All Processes
2310011501	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Connectors
2310011502	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Flanges
2310011503	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Open Ended Lines
2310011505	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Production; Fugitives: Valves
2310020600	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Natural Gas; Compressor Engines
2310020800	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Natural Gas; Gas Well Truck Loading
2310021010	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Storage Tanks: Condensate
2310021030	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Tank Truck/Railcar Loading: Condensate
2310021100	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Heaters
2310021102	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Natural Gas Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP
2310021202	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Natural Gas Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP

Emissions Modeling Platform Collaborative: 2016beta Nonpoint Oil/Gas Sources

SCC	TOOL OR STATE SCC	PRODUCTION OR EXPLORATION SCC	SCCDESC
2310021251	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Lateral Compressors 4 Cycle Lean Burn
2310021300	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Pneumatic Devices
2310021302	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP
2310021310	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Pneumatic Pumps
2310021351	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Lateral Compressors 4 Cycle Rich Burn
2310021400	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Dehydrators
2310021450	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Wellhead
2310021500	STATE	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Completion - Flaring
2310021501	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Connectors
2310021502	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Flanges
2310021503	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Open Ended Lines
2310021505	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Valves
2310021506	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: Other
2310021509	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Fugitives: All Processes
2310021601	STATE	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Venting - Initial Completions
2310021603	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Gas Well Venting - Blowdowns
2310021700	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production; Miscellaneous Engines
2310022000	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Off-Shore Gas Production; Total: All Processes
2310023010	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Storage Tanks: Condensate
2310023030	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Tank Truck/Railcar Loading: Condensate
2310023100	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; CBM Well Heaters

Emissions Modeling Platform Collaborative: 2016beta Nonpoint Oil/Gas Sources

SCC	TOOL OR STATE SCC	PRODUCTION OR EXPLORATION SCC	SCCDESC
2310023102	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; CBM Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP
2310023202	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; CBM Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP
2310023251	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Lateral Compressors 4 Cycle Lean Burn
2310023300	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Pneumatic Devices
2310023302	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; CBM Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP
2310023310	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Pneumatic Pumps
2310023351	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Lateral Compressors 4 Cycle Rich Burn
2310023400	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Dehydrators
2310023509	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Fugitives
2310023511	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Fugitives: Connectors
2310023512	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Fugitives: Flanges
2310023513	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Fugitives: Open Ended Lines
2310023515	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Fugitives: Valves
2310023516	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Fugitives: Other
2310023600	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; CBM Well Completion: All Processes
2310023603	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; CBM Well Venting - Blowdowns
2310023606	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; Coal Bed Methane Natural Gas; Mud Degassing
2310030300	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; Natural Gas Liquids; Gas Well Water Tank Losses
2310111100	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Exploration; Mud Degassing
2310111401	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Exploration; Oil Well Pneumatic Pumps

SCC	TOOL OR STATE SCC	PRODUCTION OR EXPLORATION SCC	SCCDESC
2310111700	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Oil Exploration; Oil Well Completion: All Processes
2310121100	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Exploration; Mud Degassing
2310121401	TOOL	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Exploration; Gas Well Pneumatic Pumps
2310121700	TOOL	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Exploration; Gas Well Completion: All Processes
2310321010	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production - Conventional; Storage Tanks: Condensate
2310321400	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production - Conventional; Gas Well Dehydrators
2310321603	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production - Conventional; Gas Well Venting - Blowdowns
2310400220	STATE	EXPLORATION	Industrial Processes; Oil and Gas Exploration and Production; All Processes - Unconventional; Drill Rigs
2310421010	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production - Unconventional; Storage Tanks: Condensate
2310421100	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production - Unconventional; Gas Well Heaters
2310421400	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production - Unconventional; Gas Well Dehydrators
2310421603	STATE	PRODUCTION	Industrial Processes; Oil and Gas Exploration and Production; On-Shore Gas Production - Unconventional; Gas Well Venting - Blowdowns

3. INVENTORY DEVELOPMENT METHODS

Oil and Gas Tool

EPA has developed the 2016 Nonpoint Oil and Gas Emission Estimation Tool (the “tool”) to estimate emissions for the 2016 beta version of the non-point oil and gas inventory. The tool has been previously used to estimate emissions for the 2014 NEI. Year 2016 oil and gas activity data was supplied to EPA by state air agencies and where state data is not supplied to EPA, EPA populates the 2016 beta inventory with the best available data. The tool is an Access database that utilizes county-level activity data (e.g. oil production and well counts), operational characteristics (types and sizes of equipment), and emission factors to estimate emissions. The tool creates a CSV-formatted emissions dataset covering all national nonpoint oil and gas emissions. This dataset is then converted to FF10 format for use in SMOKE modeling. A separate report named “2016 Nonpoint Oil and Gas Emission Estimation Tool V1_0

December_2018.docx” was generated that provides technical details of how the tool was applied for the 2016 beta inventory.

Alternative datasets

Some states provided, or recommended use of, a separate np_oilgas emissions inventory for use in 2016 beta platform instead of emissions derived from the Oil and Gas Tool. For example, California developed their own np_oilgas emissions inventory for 2016, and we use that inventory in place of Oil and Gas Tool output in California.

In Pennsylvania, at that state’s request, we used the np_oilgas inventory from 2016 alpha platform instead of emissions from the Oil and Gas Tool. The 2016 alpha platform np_oilgas emissions were projected from 2014NElv2, using the projection factors listed in Table 2 for CO, NOX, and VOC only. These growth factors are based on historical production data released by EIA.

In Colorado, at that state’s request, we performed a projection of 2014NElv2 instead of using data from the Oil and Gas Tool. Here, projections were applied to CO, NOX, PM, and SO2, but not VOC. Projection factors for Colorado are listed in Table 2 and are based on historical production trends.

In Oklahoma, at that state’s request, EPA projected most production np_oilgas emissions from 2014NElv2, except for lateral compressors. Projection factors for Oklahoma np_oilgas production, based on historical production data, are listed in Table 2. For lateral compressor emissions in Oklahoma, the Oil and Gas Tool inventory for 2016 was used, except with a 72% cut applied to all emissions. Exploration np_oilgas emissions in Oklahoma are based on the Oil and Gas Tool inventory for 2016, without modification.

Table 2: 2014NElv2-to-2016 oil and gas projection factors for PA, CO and OK.

State/region	Emissions type	Growth	Pollutant(s)
Pennsylvania	Oil	-7.9%	CO, NOX, VOC
Pennsylvania	Natural Gas	+24.8%	CO, NOX, VOC
Pennsylvania	Combination Oil + NG	+8.5%	CO, NOX, VOC
Pennsylvania	Coal Bed Methane	-13.6%	CO, NOX, VOC
Pennsylvania	Natural Gas Liquids	+17.8%	CO, NOX, VOC
Colorado	Oil	+22.0%	CO, NOX, SO2
Colorado	Natural Gas	+3.5%	CO, NOX, PM, SO2
Colorado	Combination Oil + NG	+12.8%	CO, NOX, PM, SO2
Oklahoma	Oil Production	+6.9%	All
Oklahoma	Natural Gas Production	+5.9%	All
Oklahoma	Combination Oil + NG Production	+6.4%	All

State/region	Emissions type	Growth	Pollutant(s)
Oklahoma	Coal Bed Methane Production	-30.0%	All

4. ANCILLARY DATA

Spatial Allocation

The exploration and production of oil and gas has increased in terms of quantities and locations over the last seven years. This increase is primarily through the use of new technologies and developments in hydraulic fracturing. Specifically, recent developments in multi-stage hydraulic fracturing combined with horizontal drilling have opened up previously unprofitable regions and rejuvenated existing regions, leading to a surge in domestic oil and gas production. ERG prepared census-tract, 2-km, and 4-km sub-county surrogate factors for 23 surrogates for EPA to use in 2016 emissions modeling. A technical memo dated December 31, 2018 by ERG provides technical details of how the gridding surrogates were generated.

Spatial allocation of np_oilgas emissions to the national 36km and 12km domains used for air quality modeling is accomplished using the spatial surrogates described in ERG’s technical memo. Spatial surrogates map county polygons to the uniformly spaced grid cells of an air quality modeling domain. All spatial surrogates for np_oilgas are developed by ERG based on known locations of known oil and gas activity for year 2016.

These spatial surrogates, numbered 670 through 699, were originally processed at 4km resolution and without gap filling. For use in 2016 beta platform, the surrogates were first gap filled using fallback surrogates. For each surrogate, the last two fallbacks were surrogate 693 (Well Count – All Wells) and 340 (Land Area). Where appropriate, other surrogates were also part of the gap filling procedure. For example, surrogate 670 (Spud Count – CBM Wells) was first gap filled with 692 (Spud Count – All Wells), and then 693 and finally 340. After gap filling, surrogates were aggregated to 12km and 36km resolution. All gap filling, and aggregating was performed with the Surrogate Tool. An additional set of spatial surrogates was provided at 9km resolution for Alaska.

A spatial surrogate cross-reference for each SCC was provided by ERG. Reports summarizing total emissions by spatial surrogate at the state and county level are included in the emissions modeling workgroup reports package. A national emissions summary by spatial surrogate is in Table 3.

Table 3. 2016ff np_oilgas emissions by spatial surrogate

Surrogate	Description	CO	NH3	NOX	PM10	PM2.5	SO2	VOC
670	Spud Count - CBM Wells	0	0	0	0	0	0	113

Surrogate	Description	CO	NH3	NOX	PM10	PM2.5	SO2	VOC
671	Spud Count - Gas Wells	0	0	0	0	0	0	6,768
674	Unconventional Well Completion Counts	5,124	12	19,127	743	731	9	1,284
678	Completions at Gas Wells	1,448	0	274	0	0	6,743	32,577
679	Completions at CBM Wells	14	0	3	0	0	80	395
681	Spud Count - Oil Wells	0	0	0	0	0	0	16,718
683	Produced Water at All Wells	778	0	11	0	0	0	47,204
685	Completions at Oil Wells	1,343	0	254	0	0	763	27,822
687	Feet Drilled at All Wells	9,696	0	38,373	1,420	1,391	27	2,785
691	Well Counts - CBM Wells	45,240	0	32,341	481	481	12	27,342
692	Spud Count - All Wells	1,930	0	8,884	272	253	99	353
693	Well Count - All Wells	0	0	0	0	0	0	159
694	Oil Production at Oil Wells	21,449	0	4,165	0	0	15,385	1,060,803
695	Well Count - Oil Wells	216,752	0	143,918	3,105	3,099	34	600,255
696	Gas Production at Gas Wells	36,628	0	16,562	1,871	1,871	166	431,037
698	Well Count - Gas Wells	396,278	0	298,879	6,193	6,173	248	645,169
699	Gas Production at CBM Wells	3,574	0	2,413	312	312	25	7,612

Temporal Allocation

Monthly temporalization of np_oilgas emissions in 2016 beta platform is based primarily on monthly factors provided by ERG. These temporal profiles are described also in the December 31, 2018 Technical Memo. Factors were provided specific to each county and SCC. For use in SMOKE, each unique set of factors was assigned a label (OG0001 through OG6323), and then a SMOKE-formatted ATPRO_MONTHLY and an ATREF were developed.

This dataset of monthly temporal factors included profiles for all counties and SCCs in the Oil and Gas Tool inventory. Because we are using non-tool datasets in some states, this monthly temporalization dataset did not cover all counties and SCCs in the entire beta platform inventory. To fill in the gaps in California, Colorado, Oklahoma, and Pennsylvania, state average monthly profiles for oil, natural gas, and combination sources were calculated from EIA data and assigned to each county/SCC combination not already covered by the ERG monthly temporal profile dataset. Coal bed methane (CBM) and natural gas liquid sources in those four

states were assigned flat monthly profiles where there was not already a profile assignment in the ERG dataset.

Because these monthly profiles are based on data that is specific to the year 2016, it may or may not be appropriate to use these profiles for other modeling years, such as 2014 or 2017. These same profiles are used in modeling of future years projected from 2016, however.

In the np_oilgas sector, all day-of-week and hour-of-day temporalization is flat.

Reports summarizing total emissions according to the monthly, day-of-week, and hour-of-day temporal profile assignments are included in the emissions modeling workgroup reports package at the state and county level.

Chemical Speciation

The np_oilgas sector includes speciation of PM_{2.5} and VOC emissions, and uses partial HAP integration for VOCs. All PM_{2.5} emissions in the np_oilgas sector use speciation profile 91145 (Petroleum Industry Average). VOC speciation relies in part on a combination GSREF file which assigns multiple profiles for certain FIPS and SCCs. Reports summarizing total PM_{2.5} and VOC emissions according to speciation profile are included in the emissions modeling workgroup reports package at the state and county level.

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

5. EMISSIONS PROJECTION METHODS

The Control Strategy Tool (CoST) was used to apply projection/growth factors and controls to emissions modeling inventories to create future year inventories for non-point oil and gas 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. This packet type is not used for the np_oilgas sector because it is a non-point inventory.
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. The PROJECTION packet(s) is used for the np_oilgas 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. The CONTROL packet(s) is used for the np_oilgas sector.

Future year projections for the 2016 beta platform were generated non-point oil and gas sources for years 2023 and 2028. These projections consisted of two components: (1) using historical and/or forecast activity data to generate future-year emissions before applicable control technologies are applied (PROJECTION or growth factors component) and (2) estimating impacts of applicable control technologies on future-year emissions (CONTROL factors component). For the growth component the oil and gas sources were separate into production-related and exploration-related sources by SCC. These sources are further subdivided by fuel-type by SCC into either OIL, natural gas (NGAS), BOTH oil-natural gas fuels possible and coal-bed methane (CBM). The next two subsections describe the growth component process.

Growth: Exploration-related sources

The list of SCCs in the 2016beta inventory that were considered exploration-related sources is given in Table 1 earlier in this document. Year 2016 was a low exploration activity year when

compared to other recent years activity. The 2016 Oil and Gas Workgroup concluded that it was not advisable to project to a future year from a base year where activity was low (see Table 4). So, year 2014 and 2016 exploration activity data were averaged and the average activity input into EPA’s Oil and Gas Tool to produce “averaged” emissions for exploration sources. Year 2014 and 2016 activity data was used because it was readily available and formatted for use in a timely manner. These averaged emissions are used for both the 2023 and 2028 future years in the 2016 beta emissions modeling platform. Note CoST was not used for this step for exploration sources. More historical years of activity will be considered in the 2016 version 1 (2016v1) modeling platform projections.

Table 4. Year 2014 and 2016 high-level summary of national oil and gas exploration activity

Grouped Parameter	2016	2014	Average
Total Well Completions	15,605	40,306	27,956
Unconventional Well Completions	7,610	20,896	14,253
Total Spuds	11,399	41,093	26,246
Total Feet Drilled	106,468,776	327,832,586	217,150,681

Table 5 provides the emissions totals (tons) after using the average of the 2014 and 2016 exploration activity data in EPA’s Oil and Gas Tool. The *Average 2014-2016 activity emissions* column is the future year emissions before any controls are applied for exploration-related non-point sources only. Note Table 5 doesn’t consider the state-submitted inventories from Colorado, Pennsylvania, California and Oklahoma.

Table 5. Future year emissions for exploration-related sources for np_oilgas sector.

Pollutant	2014 NEIv2	2016 Oil and Gas Tool before any state-submitted inventories	Average 2014-2016 activity emissions
NOX	176305	42878	83425
VOC	230024	89708	166795
PM2.5	6706	2551	4964
SO2	10303	5197	7951
CO	48205	11729	22430
PM10	6899	2635	5127

Growth: Production-related sources

The list of SCCs in the 2016beta inventory that were considered production-related sources is given in Table 1 earlier in this document. Table 6 below provides the fuel produced (SRC_TYPE) for each of these SCCs. The SRC_TYPE can be either OIL, NGAS, BOTH (oil and gas), or CBM.

Table 6. List of SCCs that were identified as production-related sources for 2016beta platform.

SCC	SRC TYPE	SCCDESC
2310000000	BOTH	Industrial Processes;Oil and Gas Exploration and Production;All Processes;Total: All Processes;;
2310000330	OIL	Industrial Processes;Oil and Gas Exploration and Production;All Processes;Artificial Lift;;
2310000550	BOTH	Industrial Processes;Oil and Gas Exploration and Production;All Processes;Produced Water;;
2310010100	OIL	Industrial Processes;Oil and Gas Exploration and Production;Crude Petroleum;Oil Well Heaters;;
2310010200	OIL	Industrial Processes;Oil and Gas Exploration and Production;Crude Petroleum;Oil Well Tanks - Flashing & Standing/Working/Breathing;;
2310010300	OIL	Industrial Processes;Oil and Gas Exploration and Production;Crude Petroleum;Oil Well Pneumatic Devices;;
2310011000	OIL	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Total: All Processes;;
2310011201	OIL	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Tank Truck/Railcar Loading: Crude Oil;;
2310011500	OIL	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: All Processes;;
2310011501	OIL	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Connectors;;
2310011502	OIL	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Flanges;;
2310011503	OIL	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Open Ended Lines;;
2310011505	OIL	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Valves;;
2310020600	NGAS	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas;Compressor Engines;;
2310020800	NGAS	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas;Gas Well Truck Loading;;
2310021010	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Storage Tanks: Condensate;;
2310021030	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Tank Truck/Railcar Loading: Condensate;;
2310021100	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Heaters;;
2310021102	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Natural Gas Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP;;
2310021202	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Natural Gas Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP;;
2310021251	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Lateral Compressors 4 Cycle Lean Burn;;
2310021300	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Pneumatic Devices;;
2310021302	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP;;

Emissions Modeling Platform Collaborative: 2016beta Nonpoint Oil/Gas Sources

SCC	SRC TYPE	SCCDESC
2310021310	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Pneumatic Pumps;;
2310021351	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Lateral Compressors 4 Cycle Rich Burn;;
2310021400	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Dehydrators;;
2310021450	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Wellhead;;
2310021501	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Connectors;;
2310021502	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Flanges;;
2310021503	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Open Ended Lines;;
2310021505	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Valves;;
2310021506	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Other;;
2310021509	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: All Processes;;
2310021603	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Venting - Blowdowns;;
2310021700	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Miscellaneous Engines;;
2310022000	NGAS	Industrial Processes;Oil and Gas Exploration and Production;Off-Shore Gas Production;Total: All Processes;;
2310023010	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Storage Tanks: Condensate;;
2310023030	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Tank Truck/Railcar Loading: Condensate;;
2310023100	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Well Heaters;;
2310023102	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP;;
2310023202	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP;;
2310023251	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Lateral Compressors 4 Cycle Lean Burn;;
2310023300	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Pneumatic Devices;;
2310023302	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP;;
2310023310	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Pneumatic Pumps;;
2310023351	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Lateral Compressors 4 Cycle Rich Burn;;
2310023400	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Dehydrators;;
2310023509	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives;;
2310023511	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Connectors;;
2310023512	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Flanges;;

SCC	SRC TYPE	SCCDESC
2310023513	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Open Ended Lines;;
2310023515	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Valves;;
2310023516	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Fugitives: Other;;
2310023603	CBM	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Well Venting - Blowdowns;;
2310030300	NGAS	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas Liquids;Gas Well Water Tank Losses;;
2310111401	OIL	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Exploration;Oil Well Pneumatic Pumps;;
2310121401	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Exploration;Gas Well Pneumatic Pumps;;
2310321010	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Conventional;Storage Tanks: Condensate;;
2310321400	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Conventional;Gas Well Dehydrators;;
2310321603	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Conventional;Gas Well Venting - Blowdowns;;
2310421010	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Unconventional;Storage Tanks: Condensate;;
2310421100	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Unconventional;Gas Well Heaters;;
2310421400	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Unconventional;Gas Well Dehydrators;;
2310421603	NGAS	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Unconventional;Gas Well Venting - Blowdowns;;

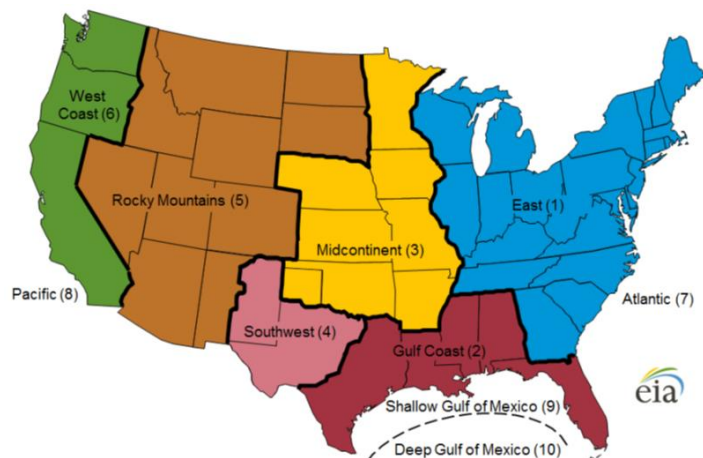
The growth factors for the SCCs in Table 6 were generated in a two-step process. The first step used historical production data at the state-level to get state-level short-term trends or factors from 2016 to year 2017. This historical data was acquired from Energy Information Administration (EIA) from the following links:

- Historical Natural Gas: http://www.eia.gov/dnav/ng/ng_sum_lsum_a_epg0_fgw_mmcf_a.htm
- Historical Crude Oil: http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbb1_a.htm
- Historical CBM: https://www.eia.gov/dnav/ng/ng_prod_coalbed_s1_a.htm

The second step involved using the Annual Energy Outlook (AEO) 2018 reference case Lower 48 forecast production tables to project from year 2017 to the years of 2023 and 2028.

Specifically, *AEO 2018 Table 60 “Lower 48 Crude Oil Production and Wellhead Prices by Supply Region”* and *AEO 2018 Table 61 “Lower 48 Natural Gas Production and Supply Prices by Supply Region”* were used in this projection process. The AEO 2018 forecast production is supplied for each EIA Oil and Gas Supply region shown in Figure 1.

Figure 1. EIA Oil and Gas Supply Regions as of AEO2018



Source: U.S. Energy Information Administration.

The result of this second step is a growth factor for each Supply region from 2017 to 2023 and from 2017 to 2028. A Supply region mapping to FIPS cross-walk was developed so the regional factors could be applied for each FIPS. Note that portions of Texas are in three different Supply Regions and portions of New Mexico are in two different supply regions. The state-level historical factor (2016 to 2017) was then multiplied by the Supply region factor (2017 to future years) to produce a state-level or FIPS-level factor to grow from 2016 to 2023 and from 2016 to 2028. This process was done using crude production forecast information to generate a factor apply to oil-production related SCCs and it was also done using natural gas production forecast information to generate a factor to apply to natural gas-production related SCCs. For the SCCs in Table 6 that are designated “BOTH” the average of the oil-production and natural-gas production factors was calculated and applied to these specific SCCs.

The coalbed methane production forecast for the AEO 2018 Reference case was available only for Lower 48 states via *AEO 2018 Table 14 Oil and Gas Supply*. This forecast was used to generate a projection factor to apply to coalbed-methane SCCs and it was applied for all lower 48 states.

The resulting changes in emissions from year 2016 to the future years of 2023 and 2028 due to the PROJECTION packet for the production-related sources is shown in Table 7. Note that the *2016 pre-CoST emissions* column in Table 7 is the sum of the 2016beta production-related source emissions plus the 2014 and 2016 emissions from the exploration-related sources.

Table 7. Emissions changes for exploration and production-related sources after application of growth method

poll	2016beta	2016 pre-CoST emissions	emissions change from 2016pre-CoST to 2023 due to PROJECTION packet	% change from 2016 to 2023	emissions change from 2016pre-CoST to 2028 due to PROJECTION packet	% change from 2016 to 2028
CO	743189	747855	143578	19.2%	198053	26.5%
NH3	12	23	0	0.0%	0	0.0%
NOX	567292	592305	98728	16.7%	137043	23.1%
PM10	14434	14979	2237	14.9%	3153	21.1%
PM25	14347	14851	2227	15.0%	3135	21.1%
SO2	23636	23894	5948	24.9%	7278	30.5%
VOC	2933607	3005399	829996	27.6%	1163941	38.7%

Controls: 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. oil and gas, Reciprocating Internal Combustion Engines (RICE), Natural Gas Turbines, and Process Heaters), we attempted to control only new sources/equipment using the following equation to account for growth and retirement of existing sources and the differences between the new and existing source emission rates.

$$Q_n = Q_o \{ [(1 + P_f)^t - 1] F_n + (1 - R_i)^t F_e + [1 - (1 - R_i)^t] F_n \} \quad \text{Equation 1}$$

where:

- Q_n = emissions in projection year
- Q_o = emissions in base year
- P_f = growth rate expressed as ratio (e.g., 1.5=50 percent cumulative growth)
- t = number of years between base and future years
- F_n = emission factor ratio for new sources
- R_i = retirement rate, expressed as whole number (e.g., 3.3 percent=0.033)
- F_e = 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 2028 projections:

$$\text{Control_Efficiency}_{2028}(\%) = 100 * (1 - [(P_{f2028}-1)*F_n + (1-R_i)^{12} + (1-(1-R_i)^{12})*F_n] / P_{f2028}) \quad \text{Equation 2}$$

Here, the existing source emissions factor (Fe) is set to 1.0, 2028 (future year) minus 2016 (base year) is 12, and new source emission factor (Fn) is the ratio of the NSPS emission factor to the existing emission factor. Table 8 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 np_oilgas sector, the Oil and Gas and RICE NSPS control programs were applied when estimating year 2023 and 2028 emissions for the 2016 beta 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 8. 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	40, (2.5%)	NO _x	Lean burn: PA, all other states	0.25, 0.606
				Rich Burn: PA, all other states	0.1, 0.069
				Combined (average) LB/RB: PA, other states	0.175, 0.338
			CO	Lean burn: PA, all other states	1.0 (n/a), 0.889
				Rich Burn: PA, all other states	0.15, 0.25
				Combined (average) LB/RB: PA, other states	0.575, 0.569
			VOC	Lean burn: PA, all other states	0.125, n/a
				Rich Burn: PA, all other states	0.1, n/a
				Combined (average) LB/RB: PA, other states	0.1125, n/a
Gas Turbines	pt_oilgas	45 (2.2%)	NO _x	California and NO _x SIP Call states	0.595
				All other states	0.238

NSPS Rule	Sector(s)	Retirement Rate years (%/year)	Pollutant Impacted	Applied where?	New Source Emission Factor (Fn)
Process Heaters	pt_oilgas	30 (3.3%)	NO _x	Nationally to Process Heater SCCs	0.41

For oil and gas NSPS controls, except for gas well completions (a 95 percent control), the assumption of no equipment retirements through year 2028 dictates that NSPS controls are applied to the growth component only of any PROJECTION factors. For example, if a growth factor is 1.5 for storage tanks (indicating a 50 percent increase activity), then, using Table 8, the 70.3 percent VOC NSPS control to this new growth will result in a 23.4 percent control: $100 * (70.3 * (1.5 - 1) / 1.5)$; this yields an “effective” growth rate (combined PROJECTION and CONTROL) of 1.1485, or a 70.3 percent reduction from 1.5 to 1.0. The impacts of all non-drilling completion VOC NSPS controls are therefore greater where growth in oil and gas production is assumed highest. Conversely, for oil and gas basins with assumed negative growth in activity/production, VOC NSPS controls will be limited to well completions only. These reductions are year-specific because projection factors for these sources are year-specific. Table 9 lists the SCCs where Oil and Gas NSPS controls were applied; note controls are applied to production and exploration-related SCCs. Table 9a shows the reduction in VOC emissions after the application of the Oil and Gas NSPS CONTROL packet for both future years 2023 and 2028.

Table 9. SCCs in 2016 beta modeling platform where Oil and Gas NSPS controls applied.

SCC	SRC TYPE	OILGAS NSPS CATEGORY	TOOL OR STATE SCC	SRC CAT TYPE	SCCDESC
2310010200	Oil	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Crude Petroleum;Oil Well Tanks - Flashing & Standing/Working/Breathing;;
2310010300	Oil	3. Pnuematic controllers: not high or low bleed	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Crude Petroleum;Oil Well Pneumatic Devices;;
2310011500	Oil	5. Fugitives	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: All Processes;;
2310011501	Oil	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Connectors;;
2310011502	Oil	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Flanges;;
2310011503	Oil	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Open Ended Lines;;

SCC	SRC TYPE	OILGAS NSPS CATEGORY	TOOL OR STATE SCC	SRC CAT TYPE	SCDESC
2310011505	Oil	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Production;Fugitives: Valves;;
2310021010	Gas	1. Storage Tanks	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Storage Tanks: Condensate;;
2310021300	Gas	3. Pneumatic controllers: not high or low bleed	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Pneumatic Devices;;
2310021310	Gas	6. Pneumatic Pumps	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Pneumatic Pumps;;
2310021501	Gas	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Connectors;;
2310021502	Gas	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Flanges;;
2310021503	Gas	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Open Ended Lines;;
2310021505	Gas	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Valves;;
2310021506	Gas	5. Fugitives	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: Other;;
2310021509	Gas	5. Fugitives	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Fugitives: All Processes;;
2310021601	Gas	2. Well Completions	STATE	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Gas Well Venting - Initial Completions;;
2310030300	Gas	1. Storage Tanks	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas Liquids;Gas Well Water Tank Losses;;
2310111401	Oil	6. Pneumatic Pumps	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Exploration;Oil Well Pneumatic Pumps;;
2310111700	Oil	2. Well Completions	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Oil Exploration;Oil Well Completion: All Processes;;
2310121401	Gas	6. Pneumatic Pumps	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Exploration;Gas Well Pneumatic Pumps;;

SCC	SRC TYPE	OILGAS NSPS CATEGORY	TOOL OR STATE SCC	SRC CAT TYPE	SCCDESC
2310121700	Gas	2. Well Completions	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Exploration;Gas Well Completion: All Processes;;
2310321010	Gas	1. Storage Tanks	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Conventional;Storage Tanks: Condensate;;
2310421010	Gas	1. Storage Tanks	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production - Unconventional;Storage Tanks: Condensate;;

Table 9a. Emissions reductions due to application of Oil and Gas NSPS.

year	poll	2016beta	2016 pre-CoST emissions	emissions change from 2016	% change
2023	VOC	2933607	3005399	-602705	-20.1%
2028	VOC	2933607	3005399	-768735	-25.6%

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 8. Table 10 lists the SCCs where RICE NSPS controls were applied for the 2016 beta platform. Table 10a shows the reduction in CO, NOx and VOC emissions after the application of the RICE NSPS CONTROL packet for both future years 2023 and 2028. Note VOC reductions only were appropriate in the state of Pennsylvania.

Table 10. SCCs in 2016 beta modeling platform where RICE NSPS controls applied.

SCC	Lean, Rich, or Combined category	SRC_TYPE	TOOL OR STATE SCC	SRC CAT TYPE	SCCDESC
2310000220	Combined	BOTH	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;All Processes;Drill Rigs;;
2310000660	Combined	BOTH	TOOL	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;All Processes;Hydraulic Fracturing Engines;;

SCC	Lean, Rich, or Combined category	SRC_TYPE	TOOL OR STATE SCC	SRC CAT TYPE	SCCDESC
2310020600	Combined	NGAS	STATE	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Natural Gas;Compressor Engines;;
2310021202	Lean	NGAS	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Natural Gas Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP;;
2310021251	Lean	NGAS	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Lateral Compressors 4 Cycle Lean Burn;;
2310021302	Rich	NGAS	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP;;
2310021351	Rich	NGAS	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;On-Shore Gas Production;Lateral Compressors 4 Cycle Rich Burn;;
2310023202	Lean	CBM	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP;;
2310023251	Lean	CBM	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Lateral Compressors 4 Cycle Lean Burn;;
2310023302	Rich	CBM	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;CBM Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP;;
2310023351	Rich	CBM	TOOL	PRODUCTION	Industrial Processes;Oil and Gas Exploration and Production;Coal Bed Methane Natural Gas;Lateral Compressors 4 Cycle Rich Burn;;
2310400220	Combined	BOTH	STATE	EXPLORATION	Industrial Processes;Oil and Gas Exploration and Production;All Processes - Unconventional;Drill Rigs;;

Table 10a. Emissions reductions due to application of RICE NSPS.

year	poll	2016beta	2016 pre-CoST emissions	emissions reduction	% change
2023	CO	743189	747855	-111627	-14.9%
2023	NOX	567292	592305	-112540	-19.0%
2023	VOC	2933607	3005399	-1108	-0.01%
2028	CO	743189	747855	-159545	-21.3%
2028	NOX	567292	592305	-164105	-27.7%
2028	VOC	2933607	3005399	-2017	-0.1%

6. EMISSIONS PROCESSING REQUIREMENTS

The np_oilgas sector emissions are processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE¹) modeling system version 4.6. All np_oilgas sector inventories are annual. Since all day-of-week temporalization is flat, we could model this sector with a single representative day per month. However, to be consistent with the nonpt sector, we process this sector with seven representative days per month (one for each day of the week), plus holidays. This is a 2-D sector in which all emissions are output to a single layer gridded emissions file.

7. EMISSIONS SUMMARIES

National and state totals by pollutant for the beta platform cases are provided here. Plots and maps are available online through the LADCO website² and the Intermountain West Data Warehouse³.

The case descriptions are as follows:

2011en, 2023en, 2028el = Final 2011, 2023, and 2028 cases from the 2011v6.3 platform

2014fd = 2014NElv2 and 2014 NATA

2016fe = 2016 alpha platform (grown from 2014NElv2)

2016ff, 2023ff and 2028ff = 2016, 2023 and 2028 cases from 2016 beta platform

Table 11. Comparison of national total annual CAPS np_oilgas emissions (tons/yr)

¹ <http://www.smoke-model.org/index.cfm>

² <https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/>

³ <http://views.cira.colostate.edu/iwdw/eibrowser2016>

Pollutant	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
CO	637,716	664,161	645,039	743,189	691,797	779,806	822,234	786,362
NH3	0	15	15	12	0	23	0	23
NOX	668,418	690,642	678,563	567,292	672,243	578,493	744,504	565,243
PM10	17,819	17,798	17,798	14,434	24,815	17,216	31,700	18,132
PM2.5	16,368	17,532	17,532	14,347	21,821	17,078	28,822	17,987
SO2	17,430	39,025	39,025	23,636	49,905	29,841	42,785	31,172
VOC	2,611,994	3,058,936	3,012,127	2,933,607	3,094,534	3,231,582	2,174,463	3,398,588

Table 12. Comparison of state total annual NOx np_oilgas emissions (tons/yr)

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Alabama	10,823	9,113	7,889	8,792	6,853	7,520	6,960	6,709
Alaska	1,349	2,348	2,364	2,090	1,348	2,127	1,348	2,127
Arizona	15	15	3	9	14	10	25	10
Arkansas	11,419	7,168	5,720	5,521	7,312	5,473	8,864	5,079
California	2,282	2,274	2,518	1,877	1,599	1,544	1,663	1,433
Colorado	37,008	34,088	36,605	36,645	53,977	26,486	45,555	25,642
Florida	55	16	15	20	47	23	72	23
Idaho		5	5	12		11		10
Illinois	8,495	8,495	7,732	23,478	7,039	22,657	15,983	22,571
Indiana	6,187	4,916	4,065	3,516	5,358	3,322	13,182	3,222
Kansas	56,387	61,891	50,981	49,832	36,901	44,893	44,876	43,560
Kentucky	24,056	11,467	10,695	15,903	18,763	14,381	46,907	13,637
Louisiana	45,871	31,746	27,894	28,442	29,248	28,912	52,810	27,706
Maryland	12	2	3	1	10	1	18	0
Michigan	11,048	10,137	8,637	11,665	7,157	10,181	24,751	9,208
Minnesota	0				0		0	
Mississippi	3,394	9	7	2,806	2,603	2,666	3,843	2,519
Missouri	17	236	143	536	13	499	16	531
Montana	4,422	4,421	3,612	2,237	4,481	2,863	7,269	2,940
Nebraska	896	3	2	520	615	481	681	472
Nevada	19	11	10	3	14	4	28	4
New Mexico	41,430	37,018	37,573	33,143	42,987	32,206	34,742	30,056
New York	605	636	420	627	350	527	293	492
North Dakota	18,687	35,597	38,963	14,572	38,001	21,091	27,198	21,503
Ohio	319	5,195	11,853	1,668	1,347	2,094	488	2,153

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Oklahoma	66,436	73,204	76,957	56,046	56,318	58,021	50,493	56,651
Oregon	41	33	27	15	31	10	29	10
Pennsylvania	40,563	19,573	22,441	22,441	60,965	20,921	61,553	21,805
South Dakota	243	218	163	98	243	140	425	148
Tennessee	1,548	1,163	846	757	1,267	696	3,004	667
Texas	222,695	256,090	246,300	179,392	220,657	198,538	218,243	191,394
Utah	13,558	15,340	12,168	8,300	15,287	10,604	21,746	11,620
Virginia	9,577	9,934	8,602	10,199	6,437	8,682	9,707	7,748
West Virginia	21,472	25,734	32,183	29,249	36,130	32,522	29,175	34,315
Wyoming	7,491	22,540	21,161	16,882	8,870	18,386	12,556	19,276

Table 13. Comparison of state total annual VOC np_oilgas emissions (tons/yr)

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Alabama	21,312	17,909	15,356	15,600	15,764	14,726	14,265	13,713
Alaska	128,138	25,670	25,838	25,211	128,138	25,404	53,144	25,404
Arizona	68	62	10	47	69	53	49	55
Arkansas	12,553	12,420	10,132	12,539	7,708	11,937	5,197	11,863
California	14,278	110,267	100,936	7,505	15,209	5,908	12,810	5,481
Colorado	250,483	83,334	86,637	83,334	305,879	88,037	137,343	80,614
Florida	2,514	926	833	916	2,443	1,079	2,022	1,040
Idaho		9	9	514		458		450
Illinois	27,437	27,437	24,833	117,342	22,784	114,188	19,683	114,172
Indiana	10,799	17,391	13,233	13,373	9,971	13,115	11,188	13,115
Kansas	93,310	97,094	77,213	89,595	61,692	86,671	33,325	89,286
Kentucky	29,912	28,363	25,270	40,564	25,273	39,111	43,866	39,110
Louisiana	112,560	67,314	57,030	57,592	75,078	66,448	80,656	65,853
Maryland	10	4	6	1	10	1	29	1
Michigan	31,712	25,217	21,105	22,656	21,384	21,066	41,586	19,519
Minnesota	0				0		0	
Mississippi	23,665	11	10	11,382	19,726	12,074	17,735	12,182
Missouri	57	533	328	1,165	45	1,092	17	1,148
Montana	45,926	49,941	39,337	40,619	50,813	41,406	56,229	44,306
Nebraska	2,524	4	3	2,774	1,769	2,590	887	2,737

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Nevada	448	219	194	169	311	195	527	214
New Mexico	125,358	173,068	190,403	180,794	160,310	207,470	78,540	212,122
New York	8,205	6,718	4,409	6,571	4,603	5,473	8,173	5,473
North	186,604	474,440	456,283	450,336	430,153	490,384	297,903	531,787
Ohio	10,178	14,658	30,475	15,559	47,927	15,726	12,379	16,368
Oklahoma	182,577	181,350	191,091	179,035	168,238	188,672	80,363	190,413
Oregon	53	44	36	32	43	19	17	17
Pennsylvania	18,618	118,844	145,977	145,977	38,438	180,636	39,610	232,359
South	2,981	2,904	2,232	2,282	3,183	2,381	3,565	2,527
Tennessee	3,057	4,065	2,951	2,058	2,653	1,867	3,015	1,906
Texas	980,334	1,087,020	1,072,820	1,136,375	1,147,192	1,285,519	826,898	1,323,051
Utah	120,944	111,880	86,705	78,696	121,332	82,427	93,196	91,518
Virginia	8,354	12,161	10,579	11,736	5,354	10,712	11,981	9,987
West	46,863	100,782	127,204	108,456	104,163	137,441	129,133	162,859
Wyoming	110,160	206,876	192,649	72,803	96,880	77,294	59,131	77,937