June 10, 2019

SPECIFICATION SHEET: PT_OILGAS

Description: Point oil and gas (pt_oilgas) emissions, for simulating 2016 and future year U.S. air quality

1. Executive Summary

The pt_oilgas sector consists of point source oil and gas emissions in United States, partly from a 2016 EPA point inventory, and partly from a projection of 2014 National Emissions Inventory (NEI) version 2 to 2016. It also includes the federally-own oil and gas sources in the Gulf of Mexico. Base year inventories were processed with the Sparse Matrix Operator 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. A summary of the methods to generate future year emissions inventories for years 2023 and 2028 is also provided.

2. INTRODUCTION

This document details the approach and data sources to be used for developing 2016 emissions for the point oil and gas (pt_oilgas) sector, which consists of oil and gas exploration, production, and distribution sources, both onshore and offshore, from the 2016 NEI Point inventory.

The starting point for the 2016 beta platform pt_oilgas inventory is the 2016 point source National Emissions Inventory (NEI). The 2016 inventory includes data submitted by state / tribal / local agencies and EPA to EPA's Emission Inventory System (EIS) for Type A (i.e., large) point sources. Point sources in the 2014 NEI not submitted for 2016 pulled are forward from the 2014 NEI unless they have been marked as shut down. The full point inventory is first split into separate components for the point emissions modeling sectors: ptegu, ptnonipm, and pt_oilgas. Sources in the pt_oilgas sector consist of sources which are not EGUs (i.e. IPM_YN is blank) and which have a North American Industry Classification System (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 Table 1. Further inventory preparation steps are outlined in the next section.

For the federally-owned offshore point inventory of oil and gas platforms, a 2014 inventory was developed by the U.S. Department of the Interior, Bureau of Ocean and Energy Management, Regulation, and Enforcement(BOEM) and further information on this inventory can be found at https://www.boem.gov/2014-Gulfwide-Emission-Inventory/.

Table 1: NAICS codes for pt_oilgas sector

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

3. BASE YEAR INVENTORY DEVELOPMENT METHODS

2016 point inventory from EIS

The 2016 pt_oilgas inventory includes both sources with updated data for 2016, and sources carried forward from the 2014NEIv2 point inventory. Each type of source can be identified based on the *calc_year* field, which is set to either 2016 or 2014. The pt_oilgas inventory was split into two components: one for 2016 sources, and one for 2014 sources. The 2016 sources were used in beta platform without further modification. The 2014 sources were projected to 20106 as described in the next section. Updates were made to selected West Virginia Type B facilities based on comments from the state.

Projection to year 2016 from 2014NEIv2

For pt_oilgas emissions that were carried forward from 2014NEIv2, the emissions were projected to represent the year 2016. Each state/SCC/NAICS combination in the inventory was classified as either an oil source, a natural gas source, a combination of oil and gas, or designated as a "no growth" source. Growth factors were based on historical state production data from Energy Information Administration (EIA) and are listed in Table 2. National 2016 pt_oilgas emissions before and after application of 2014-to-2016 projections are shown in Table 3. The historical production data for years 2014 and 2016 for oil and natural gas were taken from the following websites:

- https://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm (Crude production)
- http://www.eia.gov/dnav/ng/ng_sum_lsum_a_epg0_fgw_mmcf_a.htm (Natural gas production)

The "no growth" sources include all offshore and tribal land emissions, and all emissions with a NAICS code associated with distribution, transportation, or support activities. Idaho had no 2014 production data from EIA so assumed no growth for this state but the only sources in Idaho for this sector were pipeline transportation related. Maryland and Oregon had no oil production data on the EIA website. The factors provided in Table 2 were applied to sources with NAICS = 2111, 21111, 211111, 211112, and 213111 and with production-related SCC processes.

Table 2: 2014NEIv2-to-2016 projection factors for pt_oilgas sector for 2016beta inventory

State	Natural Gas growth	Oil growth	Combination gas/oil growth
Alabama	-9.0%	-17.5%	-13.2%
Alaska	1.9%	-1.1%	0.4%
Arizona	-55.7%	-85.7%	-70.7%

State	Natural Gas growth	Oil growth	Combination gas/oil growth
Arkansas	-26.7%	13.6%	-6.6%
California	-14.2%	-9.1%	-11.7%
Colorado	3.5%	22.0%	12.8%
Florida	8.0%	-13.2%	-2.6%
Idaho	0.0%	0.0%	0.0%
Illinois	13.2%	-9.5%	1.8%
Indiana	-6.2%	-27.5%	-16.9%
Kansas	-15.0%	-23.4%	-19.2%
Kentucky	-1.6%	-23.1%	-12.4%
Louisiana	-11.0%	-17.4%	-14.2%
Maryland	70.0%	N/A	N/A
Michigan	-12.6%	-23.4%	-18.0%
Mississippi	-10.9%	-16.3%	-13.6%
Missouri	-66.7%	-37.2%	-52.0%
Montana	-11.9%	-22.5%	-17.2%
Nebraska	27.3%	-25.0%	1.2%
Nevada	0.0%	-12.3%	-6.2%
New Mexico	1.4%	17.4%	9.4%
New York	-33.4%	-36.8%	-35.1%
North Dakota	31.4%	-4.3%	13.6%
Ohio	181.0%	44.4%	112.7%
Oklahoma	5.9%	6.9%	6.4%
Oregon	-18.0%	N/A	N/A
Pennsylvania	24.8%	-7.9%	8.5%
South Dakota	-33.9%	-21.7%	-27.8%
Tennessee	-31.9%	-22.1%	-27.0%
Texas	-6.1%	1.0%	-2.6%
Utah	-19.8%	-25.4%	-22.6%
Virginia	-10.0%	-50.0%	-30.0%
West Virginia	28.9%	0.7%	14.8%
Wyoming	-7.5%	-4.7%	-6.1%

Table 3. 2016ff pt_oilgas national emissions (excluding offshore) before and after 2014-to-2016 projections

Pollutant	Before projections	After projections	% change 2014 to 2016
CO	175,929	178,093	1.2%
NH3	4,347	4,338	-0.2%
NOX	377,517	380,026	0.7%
PM10-PRI	12,630	12,570	-0.5%
PM25-PRI	11,545	11,477	-0.6%
SO2	35,236	34,878	-1.0%
VOC	127,242	129,325	1.6%

4. Ancillary Data

Spatial Allocation

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

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. The pt_oilgas sector does not use the same monthly profiles as np_oilgas, since those monthly profiles are specific to area sources derived from the Oil and Gas Tool.

Chemical Speciation

The pt_oilgas 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.

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 facility closures, projection/growth factors and controls to emissions modeling inventories to create future year inventories for 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-analysismodelstools-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 used for the pt_oilgas sector.
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 pt_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 pt_oilgas sector.

Future year projections for the 2016 beta platform were generated for point oil and gas sources 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). Applying the CLOSURE packet to the pt_oilgas sector resulted in small emissions changes in national summary shown in Table 4. Note the closures for years 2023 and 2028 are the same.

Table 4. Emissions reductions for years 2023 and 2028 due to source closures.

poll	2016beta emissions (tons)	emissions reductions due to closures (tons)	% change
CO	228145	-190	-0.08%
NH3	4353	0	0.00%
NOX	428717	-285	-0.07%
PM10	13237	-9	-0.07%
PM25-PRI	12143	-9	-0.07%

poll	2016beta emissions (tons)	emissions reductions due to closures (tons)	% change
SO2	35380	-178	-0.50%
VOC	177534	-109	-0.06%
CO	228145	-190	-0.08%
NH3	4353	0	0.00%
NOX	428717	-285	-0.07%
PM10	13237	-9	-0.07%
PM25	12143	-9	-0.07%
SO2	35380	-178	-0.50%
VOC	177534	-109	-0.06%

For the growth component, oil and gas sources were separate into production-related and all other point sources by NAICS. These sources are further subdivided by fuel-type by SCC into either OIL, natural gas (NGAS), and BOTH oil-natural gas fuels possible. The next two subsections describe the growth component process.

Growth: Production-related sources

The list of NAICSs in the 2016beta inventory that were considered production-related sources is given in Table 1 earlier in this document. There are too many NAICS-SCC combinations in the pt_oilgas inventory to list in this document, however these NAICS-SCC combinations were used to determine if the fuel produced related to each individual combination was either OIL, NGAS, or BOTH (oil and gas).

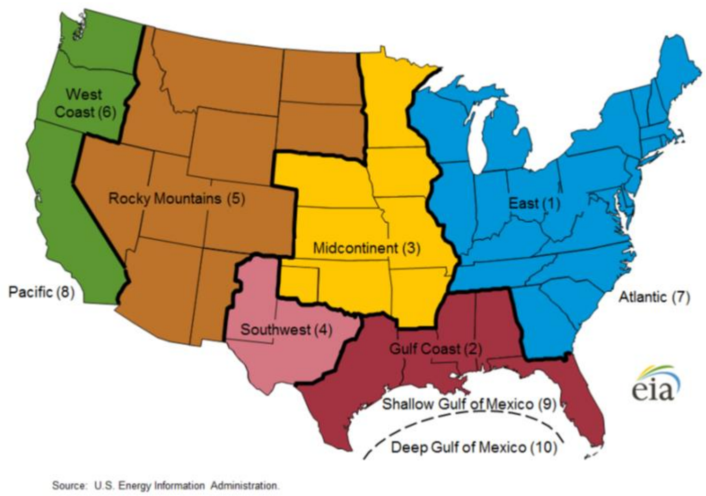
The growth factors for these NAICS-SCC combinations were generated in a two-step process. The first step used historical production data at the state-level to get state-level short-term trends or factors from 2016 to year 2017. This historical data was acquired from Energy Information Administration (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_mbbl_a.htm
- Historical CBM: https://www.eia.gov/dnav/ng/ng_prod_coalbed_s1_a.htm

The second step involved using the Annual Energy Outlook (AEO) 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



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 NAICS-SCC combinations and it was also done using natural gas production forecast information to generate a factor to apply to natural gas-production related NAICS-SCC combinations. For the NAICS-SCC combinations that are designated "BOTH" the average of the oil-production and natural-gas production factors was calculated and applied to these specific combinations. Table 5 shows a national summary in the change of emissions after applying the PROJECTION packet to the production-related point sources in the pt_oilgas sector.

Table 5. Emissions changes in tons for years 2023 and 2028 due to the application of the PROJECTION packet.

year	poll	2016beta (tons)	emissions change due to PROJECTION packet (tons)	% change
2023	CO	228145	17204	7.5%
2023	NH3	4353	3	0.1%
2023	NOX	428717	24218	5.6%
2023	PM10	13237	906	6.8%
2023	PM25	12143	858	7.1%

year	poll	2016beta (tons)	emissions change due to PROJECTION packet (tons)	% change
2023	SO2	35380	5822	16.5%
2023	VOC	177534	16132	9.1%
2028	CO	228145	21798	9.6%
2028	NH3	4353	7	0.1%
2028	NOX	428717	30628	7.1%
2028	PM10	13237	1191	9.0%
2028	PM25	12143	1121	9.2%
2028	SO2	35380	7320	20.7%
2028	VOC	177534	20877	11.8%

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.

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

where:

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

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

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

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 6 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 pt_oilgas sector, the Oil and Gas NSPS, RICE NSPS, Process Heaters NSPS, and Natural Gas Turbines 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 6. 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 6, 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. The amount of VOC emissions associated with well completions (SCC 31000101) in the point source inventory is small and limited to the states of California, Colorado, Florida, Louisiana, Oklahoma, and Texas. These reductions are year-specific because projection factors for these sources are year-specific. Table 7 lists the point source SCCs where Oil and Gas NSPS controls were applied; note controls are applied to production-related NAICS-SCC combinations (see NAICS in Table 1). Table 7a 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 7. Point source SCCs in 2016 beta modeling platform where Oil and Gas NSPS controls were applied.

SCC	FUEL PRODUCED	OILGAS NSPS CATEGORY	SCCDESC
31000101	Oil	2. Well Completions	Industrial Processes;Oil and Gas Production;Crude Oil Production;Well Completion;;
31000130	Oil	4. Compressor Seals	Industrial Processes;Oil and Gas Production;Crude Oil Production;Fugitives: Compressor Seals;;
31000133	Oil	1. Storage Tanks	Industrial Processes;Oil and Gas Production;Crude Oil Production;Storage Tank;;
31000151	Oil	3. Pnuematic controllers: high or low bleed	Industrial Processes;Oil and Gas Production;Crude Oil Production;Pneumatic Controllers, Low Bleed;;
31000152	Oil	3. Pnuematic controllers: high or low bleed	Industrial Processes;Oil and Gas Production;Crude Oil Production;Pneumatic Controllers High Bleed >6 scfh;;
31000207	Gas	5. Fugitives	Industrial Processes;Oil and Gas Production;Natural Gas Production;Valves: Fugitive Emissions;;
31000220	Gas	5. Fugitives	Industrial Processes;Oil and Gas Production;Natural Gas Production;All Equipt Leak Fugitives (Valves, Flanges, Connections, Seals, Drains;;
31000222	Gas	2. Well Completions	Industrial Processes;Oil and Gas Production;Natural Gas Production;Well Completions;;
31000225	Gas	4. Compressor Seals	Industrial Processes;Oil and Gas Production;Natural Gas

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

Table 7a. VOC reductions (tons) after the application of the Oil and Gas NSPS CONTROL packet for both future years 2023 and 2028.

year	poll	2016beta	emissions reductions	% change
2023	VOC	177534	-1590	-0.9%
2028	VOC	177534	-1886	-1.1%

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 6. Table 8 lists the point source SCCs where RICE NSPS controls were applied for the 2016 beta platform; note controls are applied to production-related NAICS-SCC combinations (see NAICS in Table 1). Table 8a shows the reduction in emissions after the application of the RICE NSPS CONTROL packet for both future years 2023 and 2028.

Table 8. Point source SCCs in 2016 beta 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	Combined	Internal Combustion Engines;Industrial;Natural Gas;4-cycle Clean Burn;;
20300201	Combined	Internal Combustion Engines;Commercial/Institutional;Natural Gas;Reciprocating;;
31000203	Combined	Industrial Processes;Oil and Gas Production;Natural Gas Production;Compressors (See also 310003-12 and -13);;

Table 8a. Emissions reductions (tons) after the application of the RICE NSPS CONTROL packet for both future years 2023 and 2028.

year	poll	2016beta (tons)	emissions reductions (tons)	% change
2023	CO	228,145	-13,294	-5.8%
2023	NOX	428,717	-29,190	-6.8%
2023	VOC	177,534	-137	-0.1%
2028	CO	228,145	-19,521	-8.6%
2028	NOX	428,717	-43,744	-10.2%
2028	VOC	177,534	-230	-0.1%

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 9 compares the 2006 NSPS emission limits with the NOx RACT regulations in selected states within the NOx SIP Call region (note the NO_x Budget Trading Program was effectively replaced by the Clean Air Interstate Rule (CAIR); see http://www3.epa.gov/airmarkets/progress/reports/program_basics.html). The map showing the states and partial-states in the NOx SIP Call Program can be found at: https://www3.epa.gov/airmarkets/progress/reports/program_basics_figures.html#figure2. We assigned only those counties in Alabama, Michigan and Missouri as NOx SIP call based on the map on page 8. The state NOx RACT regulations summary (Pechan, 2001) is from a year 2001 analysis, so some states may have updated their rules since that time.

Table 9. 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. Table 10 lists the point source SCCs where Natural Gas Turbines NSPS controls were applied for the 2016 beta platform; note controls are applied to production-related NAICS-SCC combinations (see NAICS in Table 1). Table 10a shows the reduction in NOx emissions after the application of the Natural Gas Turbines NSPS CONTROL packet for both future years 2023 and 2028.

Table 10. Point source SCCs in 2016 beta modeling platform where Natural Gas Turbines NSPS controls applied.

SCC	SCC description
20200201	Internal Combustion Engines;Industrial;Natural Gas;Turbine;;
20200209	Internal Combustion Engines;Industrial;Natural Gas;Turbine: Exhaust;;
20300202	Internal Combustion Engines;Commercial/Institutional;Natural Gas;Turbine;;
20300209	Internal Combustion Engines;Commercial/Institutional;Natural Gas;Turbine: Exhaust;;
20200203	Internal Combustion Engines;Industrial;Natural Gas;Turbine: Cogeneration;;
20200714	Internal Combustion Engines;Industrial;Process Gas;Turbine: Exhaust;;
20300203	Internal Combustion Engines;Commercial/Institutional;Natural Gas;Turbine: Cogeneration;;

Table 10a. Emissions reductions (tons) after the application of the Natural Gas Turbines NSPS CONTROL packet for both future years 2023 and 2028.

year	poll	2016beta (tons)	emissions reduction (tons)	% change
2023	NOX	428,717	-4,850	-1.1%
2028	NOX	428,717	-7,197	-1.7%

Process heaters are used throughout refineries and chemical plants to raise the temperature of feed materials to meet reaction or distillation requirements. Neither refineries nor chemical plants are included in the pt_oilgas sector. However, process heaters are often used at natural gas liquids plants and other point sources in this sector. 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 11.

Table 11. Process Heaters NSPS analysis and 2016beta new emission rates used to estimate controls

NO_X emission rate Existing (Fe)	**Fraction at this rate**		
PPMV	**Natural Draft**	**Forced Draft**	**Average**
80	0.4	0	
100	0.4	0.5	
150	0.15	0.35	
200	0.05	0.1	
240	0	0.05	
Cumulative, weighted: Fe	104.5	134.5	119.5
NSPS Standard	40	60	
New Source NO_X ratio (Fn)	0.383	0.446	**0.414**
NSPS Control (%)	61.7	55.4	58.6

For computations, the existing source emission ratio (Fe) was set to 1.0. The computed (average) NO_x emission factor ratio for new sources (Fn) is 0.41 (58.6 percent control). The retirement rate is the inverse of the expected unit lifetime. There is limited information in the literature about process heater lifetimes. This information was reviewed at the time that the Western Regional Air Partnership (WRAP) developed its initial regional haze program emission projections, and energy technology models used a 20-year lifetime for most refinery equipment. However, it was noted that in practice, heaters would probably have a lifetime that was on the order of 50 percent above that estimate. Therefore, a 30-year lifetime was used to estimate the effects of process heater growth and retirement. This yields a 3.3 percent retirement rate. This control was then plugged into *Equation 2* as a function of the year-specific projection factor. Table 12 lists the point source SCCs where Process Heaters NSPS controls were applied for the 2016 beta platform; note controls are applied to production-related NAICS-SCC combinations (see NAICS in Table 1). Table 12a shows the reduction in NOx emissions after the application of the Process Heaters NSPS CONTROL packet for both future years 2023 and 2028.

Table 12. Point source SCCs in 2016 beta modeling platform where Process Heaters NSPS controls applied.

scc	sccdesc
30190003	Industrial Processes;Chemical Manufacturing;Fuel Fired Equipment;Process Heater: Natural Gas;;
30600102	Industrial Processes;Petroleum Industry;Process Heaters;Gas-fired **;;
30600104	Industrial Processes;Petroleum Industry;Process Heaters;Gas-fired;;
30600105	Industrial Processes;Petroleum Industry;Process Heaters;Natural Gas-fired;;
30600106	Industrial Processes;Petroleum Industry;Process Heaters;Process Gas-fired;;
30600199	Industrial Processes;Petroleum Industry;Process Heaters;Other Not Classified;;
30990003	Industrial Processes;Fabricated Metal Products;Fuel Fired Equipment;Natural Gas: Process Heaters;;
31000401	Industrial Processes;Oil and Gas Production;Process Heaters;Distillate Oil (No. 2);;
31000402	Industrial Processes;Oil and Gas Production;Process Heaters;Residual Oil;;
31000403	Industrial Processes;Oil and Gas Production;Process Heaters;Crude Oil;;
31000404	Industrial Processes;Oil and Gas Production;Process Heaters;Natural Gas;;
31000405	Industrial Processes;Oil and Gas Production;Process Heaters;Process Gas;;
31000413	Industrial Processes;Oil and Gas Production;Process Heaters;Crude Oil: Steam Generators;;
31000414	Industrial Processes;Oil and Gas Production;Process Heaters;Natural Gas: Steam Generators;;
31000415	Industrial Processes;Oil and Gas Production;Process Heaters;Process Gas: Steam Generators;;
39900501	Industrial Processes;Miscellaneous Manufacturing Industries;Process Heater/Furnace;Distillate Oil;;
39900601	Industrial Processes;Miscellaneous Manufacturing Industries;Process Heater/Furnace;Natural Gas;;

Table 12a. Emissions reductions (tons) after the application of the Process Heaters NSPS CONTROL packet for both future years 2023 and 2028.

year	poll	2016beta (tons)	emissions reductions (tons)	% change
2023	NOX	428,717	-1,481	-0.3%
2028	NOX	428,717	-2,122	-0.5%

6. EMISSIONS PROCESSING REQUIREMENTS

The pt_oilgas emissions were processed for air quality modeling using the SMOKE[1] version 4.6 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 pt_oilgas 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 were 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 pt_oilgas sources. The 2-D gridded emissions from pt_oilgas must be included in the 2-D sector merge. The reason all sources were not classified as elevated sources in pt_oilgas and ptnonipm, as is done with cmv_c3 and othpt, was to limit the size of the inline point source files from these sectors.

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 website[3] and the Intermountain West Data Warehouse[4]. The case descriptions are as follows:

[1] http://www.smoke-model.org/index.cfm
[2] https://www.cmascenter.org/smoke/documentation/4.5/html/ch06s03.html#sect_programs_elevpoint_briggs
[3] https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/
[4] http://views.cira.colostate.edu/iwdw/eibrowser2016

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

2014fd = 2014NEIv2 and 2014 NATA

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

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

Table 13. Comparison of national total annual CAPS pt_oilgas emissions (tons/yr)

Pollutant	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
CO	246,377	258,374	237,926	228,145	240,910	231,865	269,315	230,232
NH3	5,947	1,340	4,373	4,353	5,917	4,355	5,950	4,359
NOX	550,571	503,674	449,476	428,717	448,424	417,129	500,064	405,996
PM10	15,611	14,646	13,688	13,237	16,345	14,135	18,235	14,419
PM2.5	14,943	14,004	12,585	12,143	15,666	12,992	17,516	13,255
SO2	68,206	49,694	43,790	35,380	66,353	41,024	90,181	42,521
VOC	165,350	185,298	182,827	177,534	178,475	191,830	199,863	196,187

Table 14. Comparison of state total annual NOx pt_oilgas emissions (tons/yr)

State Name	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Alabama	13,621	10,000	8,853	8,689	9,886	8,050	11,061	7,671
Alaska	40,715	39,296	40,554	40,586	23,829	40,586	22,928	40,586
Arizona	1,474	2,141	2,562	2,562	1,485	2,390	1,526	2,283
Arkansas	12,249	14,411	5,037	5,056	11,479	4,725	12,467	4,522
California	6,641	4,539	4,487	4,258	5,317	3,484	5,476	3,252
Colorado	30,839	23,943	23,189	24,568	35,691	23,568	41,893	22,523
Connecticut	292	347	214	214	216	194	242	181
Delaware		19	19	19		17		15
Florida	5,331	5,312	6,432	6,432	2,291	6,138	2,319	5,906
Georgia	7,075	4,603	4,419	4,419	3,293	4,378	3,193	4,354
Idaho	1,351	884	1,091	1,091	1,102	974	1,134	902
Illinois	20,561	19,761	8,620	8,620	17,101	7,875	20,257	7,421
Indiana	10,172	8,042	5,148	5,148	10,820	5,053	12,075	4,995
Iowa	9,523	7,378	5,051	5,051	485	4,941	536	4,874
Kansas	35,886	30,326	23,493	23,398	2,539	22,134	2,815	21,515
Kentucky	8,677	4,626	4,616	4,536	6,547	4,198	7,778	4,003
Louisiana	41,820	33,468	29,786	29,676	36,181	30,001	43,261	29,133
Maine	64	32	25	25	56	22	59	20
Maryland	1,340	119	157	157	1,219	152	1,177	149
Massachusetts	246	264	263	263	212	240	176	226
Michigan	16,790	13,504	10,714	10,700	13,548	9,786	15,807	9,217

State Name	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Minnesota	2,878	2,131	2,837	2,837	142	2,743	157	2,685
Mississippi	23,306	12,299	12,266	12,259	17,106	11,181	18,810	10,519
Missouri	7,211	6,856	3,979	3,979	361	3,852	399	3,774
Montana	1,481	1,407	1,348	1,347	1,283	1,223	1,321	1,146
Nebraska	3,760	4,329	3,605	3,605	790	3,367	890	3,221
Nevada	282	269	215	215	232	195	237	182
New Jersey	407	270	233	233	423	221	409	213
New Mexico	20,866	17,234	15,975	9,748	20,473	9,534	22,162	9,185
New York	1,512	1,308	1,357	1,357	1,502	1,265	1,445	1,209
North Carolina	3,056	1,199	562	562	3,308	527	2,724	506
North Dakota	5,581	5,350	5,562	5,571	5,711	5,488	5,554	5,340
Ohio	8,932	9,192	11,337	11,413	8,323	10,674	9,249	10,242
Oklahoma	61,211	61,178	58,794	46,054	54,967	42,718	65,551	40,346
Oregon	884	421	421	421	754	392	740	375
Pennsylvania	8,339	6,018	6,056	6,091	5,526	5,587	5,335	5,299
Rhode Island	27	52	59	59	26	59	26	59
South Carolina	1,543	604	667	428	857	419	871	414
South Dakota	564	433	433	433	22	417	25	407
Tennessee	6,304	3,903	4,647	4,647	4,683	4,218	5,125	3,955
Texas	76,632	65,045	53,496	53,444	91,632	56,536	102,112	56,279
Utah	3,680	2,258	2,676	2,638	2,912	2,333	2,985	2,154
Virginia	3,755	631	733	733	3,781	716	3,863	705
Washington	450	444	754	754	310	678	307	631
West Virginia	14,158	12,060	11,918	10,059	11,663	9,889	12,209	9,793
Wisconsin	603	200	534	534	531	495	587	472
Wyoming	19,566	10,092	9,307	8,850	18,988	8,518	21,949	8,165
Offshore to EEZ		48,691	48,691	48,691		48,691		48,691
Tribal Data	8,918	6,785	6,287	6,287	8,820	6,287	8,842	6,287

Table 15. Comparison of state total annual SO2 pt_oilgas emissions (tons/yr)

State Name	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Alabama	20,226	9,246	5,739	5,548	15,067	6,675	35,903	7,242
Alaska	1,629	1,699	1,649	1,653	1,363	1,653	1,338	1,653
Arizona	10	35	35	35	11	35	11	35
Arkansas	254	267	264	195	166	182	219	177
California	1,592	724	723	636	1,352	490	1,270	454
Colorado	512	522	506	514	544	562	654	563
Connecticut	2	2	3	3	2	3	2	3
Delaware		0	0	0		0		0

State Name	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Florida	884	1,427	1,527	1,527	850	2,156	854	2,277
Georgia	1	4	4	4	1	4	1	4
Idaho	5	3	6	6	5	6	5	6
Illinois	470	61	129	129	134	129	2,069	129
Indiana	77	263	87	87	78	87	410	87
Iowa	7	7	5	5	2	5	2	5
Kansas	65	43	37	37	33	36	42	36
Kentucky	125	113	113	112	104	112	260	112
Louisiana	582	790	877	865	446	1,288	960	1,380
Maine	3	1	1	1	3	1	4	1
Maryland	1	0	0	0	1	0	1	0
Massachusetts	5	2	2	2	4	2	6	2
Michigan	398	313	373	372	367	362	383	362
Minnesota	82	141	151	151	5	151	5	151
Mississippi	5,553	638	638	555	4,254	600	9,675	630
Missouri	3	5	3	3	0	3	0	3
Montana	114	106	69	69	85	69	122	69
Nebraska	6	4	3	3	1	3	1	3
Nevada	20	17	16	16	21	16	22	16
New Jersey	4	7	6	6	4	6	4	6
New Mexico	13,068	6,379	7,997	509	16,716	616	12,753	643
New York	7	29	10	10	8	10	8	10
North Carolina	4	3	2	2	4	2	4	2
North Dakota	6,676	5,125	3,860	3,883	11,042	4,120	7,387	4,097
Ohio	5	11	24	24	6	26	6	27
Oklahoma	809	649	652	279	649	301	731	295
Oregon	16	13	13	13	16	13	16	13
Pennsylvania	33	36	36	37	35	37	36	38
Rhode Island	1	1	2	2	1	2	1	2
South Carolina	15	7	7	2	13	2	15	2
South Dakota	22	1	1	1	1	1	1	1
Tennessee	5	17	4	4	4	4	4	4
Texas	10,321	14,205	12,200	12,160	9,271	15,033	10,220	15,827
Utah	29	503	582	483	29	478	26	481
Virginia	10	82	1	1	10	1	10	1
Washington	11	14	20	20	10	20	10	20
West Virginia	4	4	4	6	4	7	4	9
Wisconsin	1	0	0	0	1	0	1	0
Wyoming	4,405	5,495	4,728	4,728	3,494	5,032	4,589	4,962
Offshore to EEZ		502	502	502		502		502

State Name	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Tribal Data	136	173	177	177	136	177	136	177

Table 16. Comparison of state total annual VOC pt_oilgas emissions (tons/yr)

State Name	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Alabama	1,699	1,463	1,284	1,268	1,402	1,413	1,894	1,476
Alaska	1,253	1,375	1,689	1,689	1,122	1,689	1,108	1,689
Arizona	90	221	187	187	96	187	94	187
Arkansas	639	891	438	438	674	436	732	435
California	4,357	3,935	3,858	3,680	3,976	2,650	3,650	2,496
Colorado	47,518	23,897	23,059	23,943	62,342	27,086	66,797	27,745
Connecticut	43	30	86	86	42	86	46	86
Delaware		5	5	5		5		5
Florida	563	558	638	638	255	589	265	598
Georgia	622	592	559	559	298	559	289	559
Idaho	39	25	30	30	40	30	41	30
Illinois	1,748	1,702	1,348	1,348	1,747	1,343	2,629	1,343
Indiana	555	400	353	353	614	353	693	353
Iowa	351	345	290	290	20	290	22	290
Kansas	4,015	3,720	2,977	2,979	1,744	2,903	1,757	2,891
Kentucky	1,321	1,141	1,123	1,104	1,098	1,080	3,844	1,080
Louisiana	11,677	11,233	11,152	11,098	10,850	14,218	14,767	14,882
Maine	51	69	53	53	51	53	51	53
Maryland	268	53	39	39	268	39	268	39
Massachusetts	66	79	78	78	76	78	67	78
Michigan	1,890	1,662	1,319	1,303	1,489	1,231	3,996	1,174
Minnesota	131	89	166	166	48	166	48	166
Mississippi	3,356	1,529	1,481	1,450	2,820	1,484	4,700	1,494
Missouri	335	350	220	220	74	220	63	220
Montana	1,069	896	924	925	1,146	931	1,190	942
Nebraska	415	343	312	312	251	312	263	312
Nevada	59	63	61	56	59	63	60	69
New Jersey	86	91	125	125	105	125	105	125
New Mexico	4,596	5,087	4,825	3,018	5,445	3,372	4,886	3,455
New York	422	463	447	447	473	447	444	447
North Carolina	546	236	144	144	622	141	523	141
North Dakota	608	1,189	1,298	1,299	880	1,399	640	1,413
Ohio	536	1,012	1,619	1,691	1,409	2,175	1,058	2,522
Oklahoma	30,066	33,574	33,783	29,946	28,718	31,735	31,110	32,335
Oregon	83	29	29	29	75	29	74	29

State Name	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Pennsylvania	1,242	1,395	1,434	1,408	1,038	1,361	1,020	1,350
Rhode Island	16	37	33	33	16	33	18	33
South Carolina	173	124	114	74	118	74	114	74
South Dakota	15	9	9	9	1	9	1	9
Tennessee	307	231	340	340	243	340	265	340
Texas	24,576	22,703	23,395	23,382	26,362	28,588	26,864	29,900
Utah	480	401	434	434	461	453	446	467
Virginia	385	167	112	112	394	112	406	112
Washington	30	36	43	43	25	43	24	43
West Virginia	3,220	2,307	2,518	2,454	2,394	2,939	3,145	3,318
Wisconsin	201	212	225	225	203	225	205	225
Wyoming	11,192	9,249	8,409	8,262	14,673	8,973	16,943	9,392
Offshore to EEZ		48,210	48,210	48,210		48,210		48,210
Tribal Data	2,439	1,872	1,551	1,551	2,218	1,551	2,240	1,551