U.S. NATIONAL OIL AND GAS EMISSION INVENTORY IMPROVEMENTS

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OVERVIEW

- **O&G Point Sources**
  - S/L/T agency survey
- **O&G Nonpoint Sources**
  - Well type definitions
  - GHGRP Subpart W data
  - Engine emission factors
  - Emission control effects on future year forecasts

O&G SECTOR

Production & Processing

Well-site

1. Drilling and Well Completion
2. Producing Wells
   a. Onshore Wells
   b. Offshore Wells

Midstream

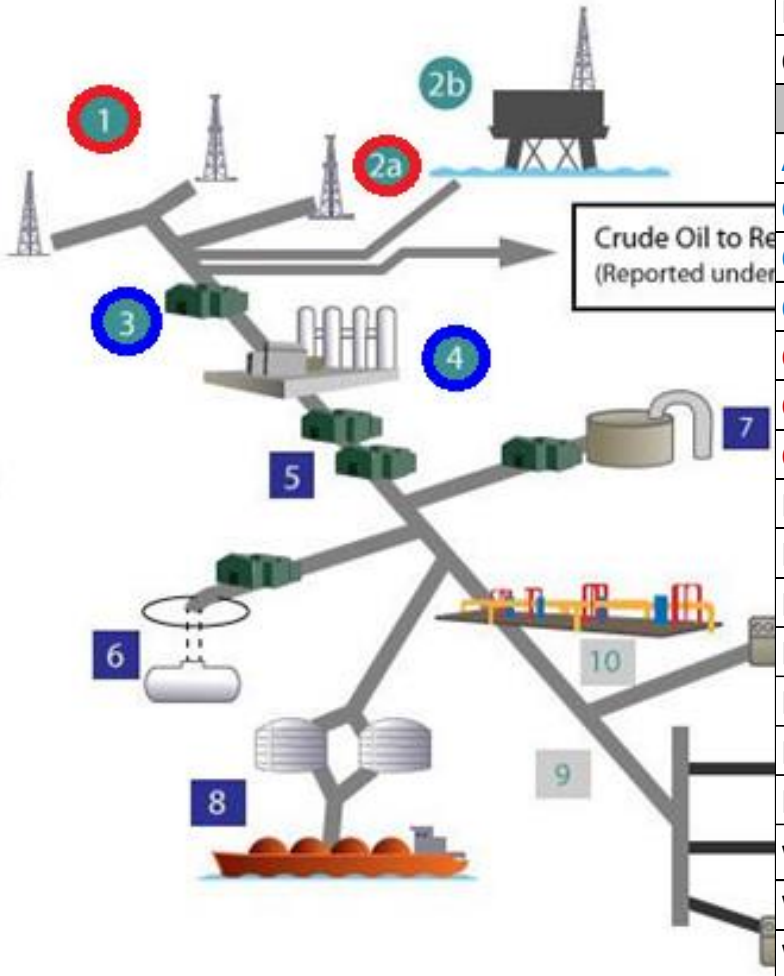
3. Gathering and Boosting (not covered by Subpart W)
4. Gas Processing Plant

Natural Gas Transmission & Storage

5. Transmission Compressor Stations
6. Underground Storage
7. LNG Storage
8. LNG Import-Export Equipment

Distribution

9. Distribution Mains/Services
10. Regulators and Meters

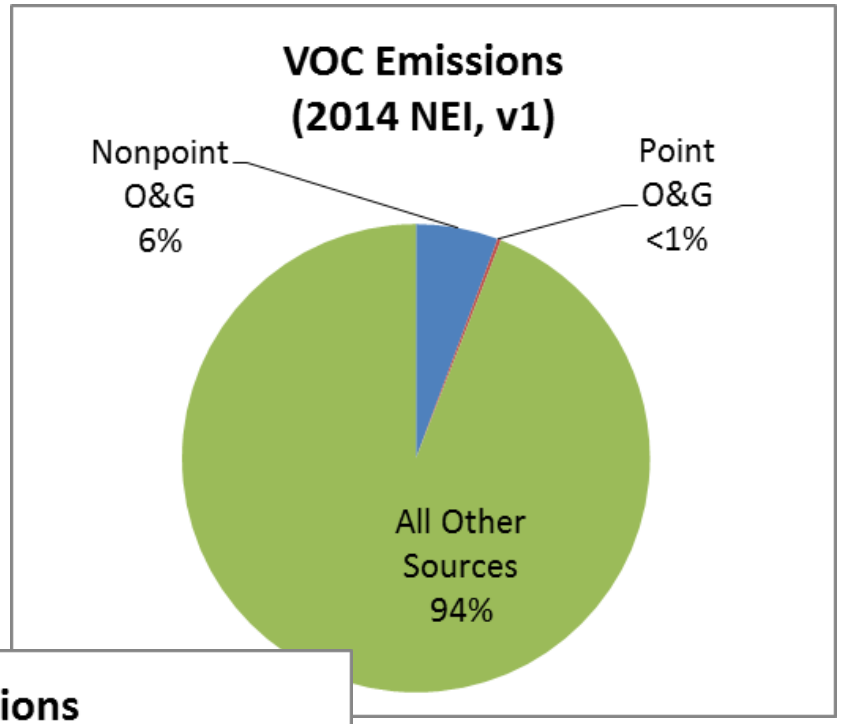


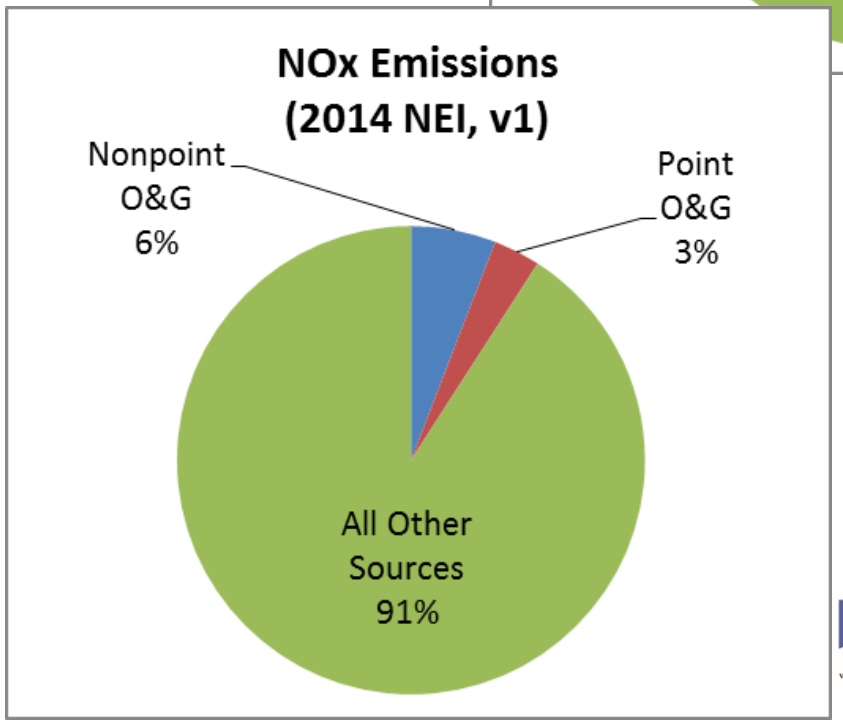
Well-site Emission Source	Oil Wells	Gas Wells
#1: Development		
Drill Rigs	✓	✓
Fracing Engines	✓	✓
Completion Venting/Flaring	✓	✓
#2a: Production		
Artificial Lift Engines	✓	
Casinghead Gas	✓	
Oil Tanks	✓	
Oil Truck Loading	✓	
Condensate Truck Loading		✓
Condensate tanks		✓
Compressor Engines		✓
Dehydrators	✓	✓
Heaters	✓	✓
Fugitive Components	✓	✓
Liquids Unloading	✓	✓
Pneumatic Controllers	✓	✓
Pneumatic Pumps	✓	✓
Refracing Engines	✓	✓
Water Pump Engines[A]	✓	✓
Water Tanks	✓	✓
Workover Rigs	✓	✓
[A] Important source for CBM wells		

source: https://www.epa.gov/ghgreporting/subpart-w-basic-information

EMISSIONS SUMMARY

- O&G emissions make substantial contributions to national inventory
- Regional contributions expected to be higher in active O&G basins
- Considerable uncertainties in point and nonpoint source O&G emission inventories persist





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MIDSTREAM O&G POINT SOURCE S/L/T AGENCY SURVEY

- Understand potential for missing facilities
- Solicited information from S/L/T agencies on NEI reporting thresholds:
  - Title V (AERR Type B)
  - Minor sources
- Surveys sent to 31 S/L/T agencies (100% response rate)
  - Prioritized states with substantial natural gas production

State	Agency
AERR Type B Only	
Alabama	ADEM
Arkansas	ARDEQ
Idaho	IDEQ
Kansas	KDHE
Maryland	MDE
Nebraska	NDEQ
New Mexico	NMED
New York	NYDEC
North Dakota	NDDOH
Pennyslvania	Alleghency CHD
Tennessee	TNDEC
Utah	UDAQ
West Virginia	WVDAQ

State	Agency	Criteria Air Pollutant Point Source Reporting Threshold
AERR Type B + Minor Sources		
Alaska	ADEC	attempted capture of all facilities
Pennsylvania	PADEP	
Wyoming	WYDEQ	0.001 tpy
Missouri	MDNR	0.438 tpy VOC, PM10, PM2.5 1 tpy NOx, CO, SO2
Colorado	CDPHE	1 tpy (NAA) 2 tpy (AA)
North Carolina	NCDEQ	5 tpy
Oklahoma	ODEQ	40 tpy (actual) 100 tpy (potential) NESHAP/NSPS Applicable Facilities
Louisiana	LDEQ	10 tpy VOC (NAA only) 25 tpy NOx (NAA only)
New Jersey	NJDEP	10 tpy VOC 25 tpy NOx
Texas	TCEQ	Actual: 10/100 tpy (VOC), 25/100 tpy (NOx)
		Potential: 25-100 tpy (VOC), 25-100 tpy (NOx)
Montana	MTDEQ	25 tpy
Ohio	OHEPA	Synthetic Minors

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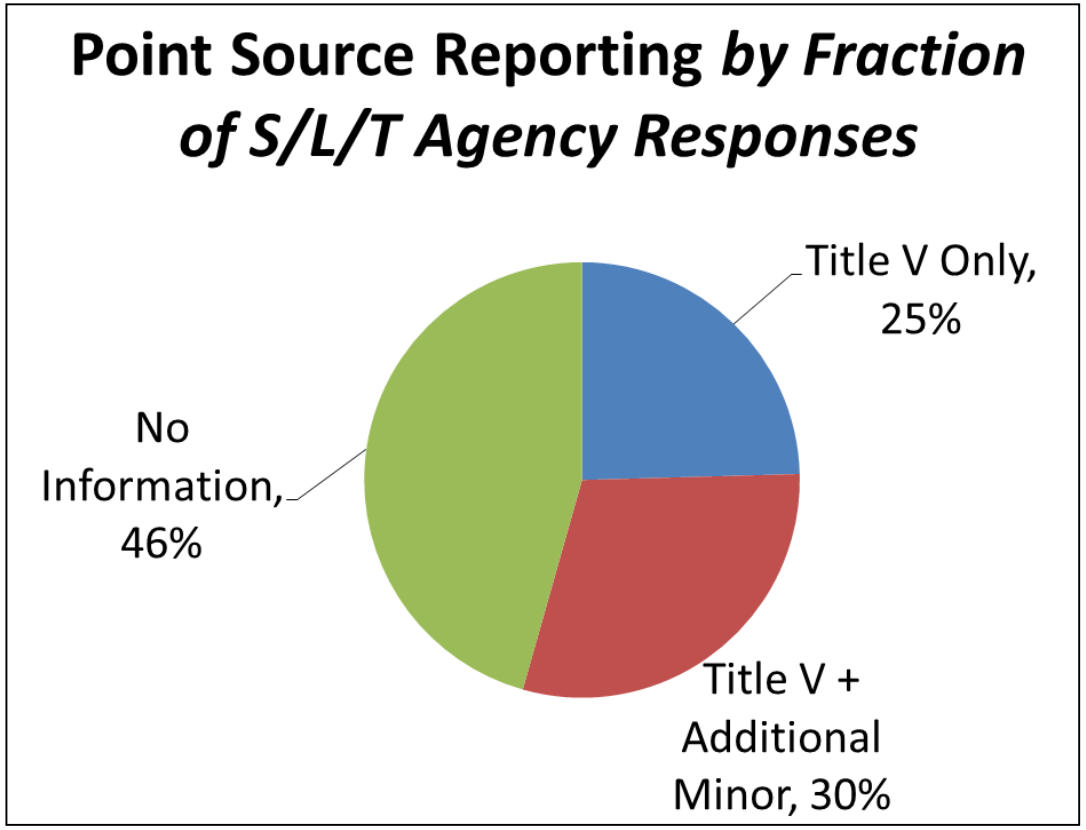
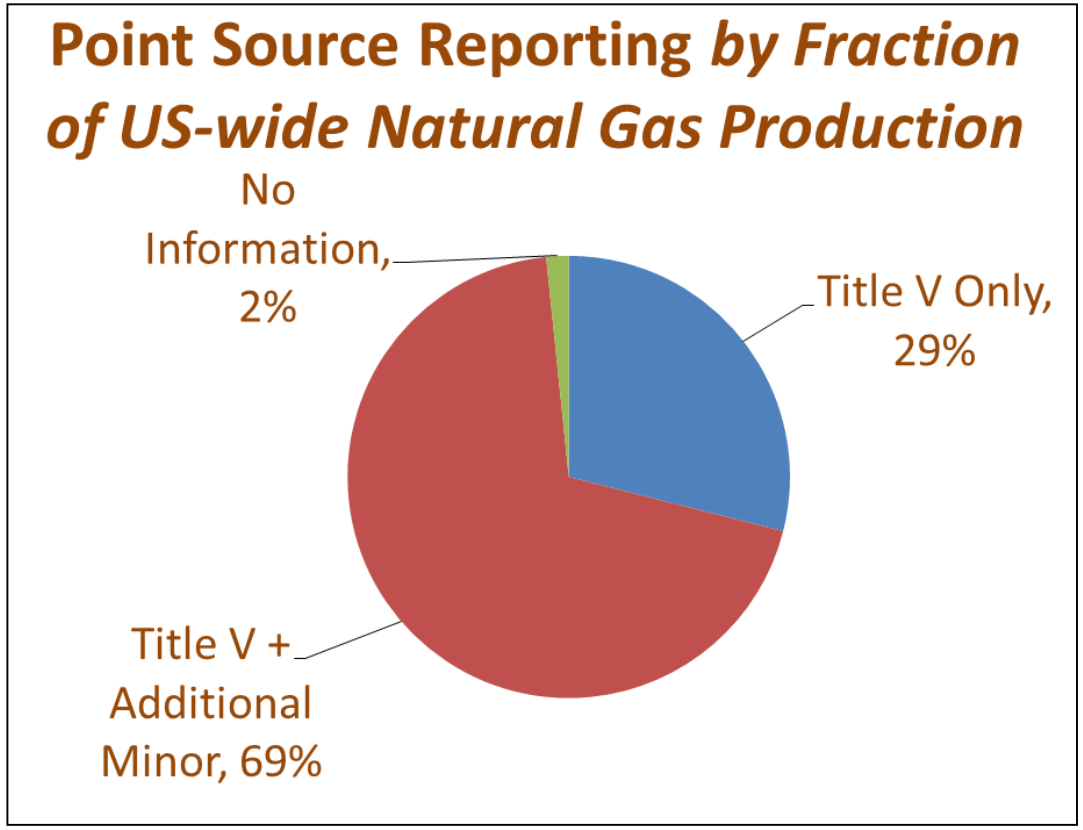
MIDSTREAM O&G POINT SOURCE S/L/T AGENCY SURVEY





2014 NEI V1 O&G POINT SOURCE EMISSIONS BY STATE

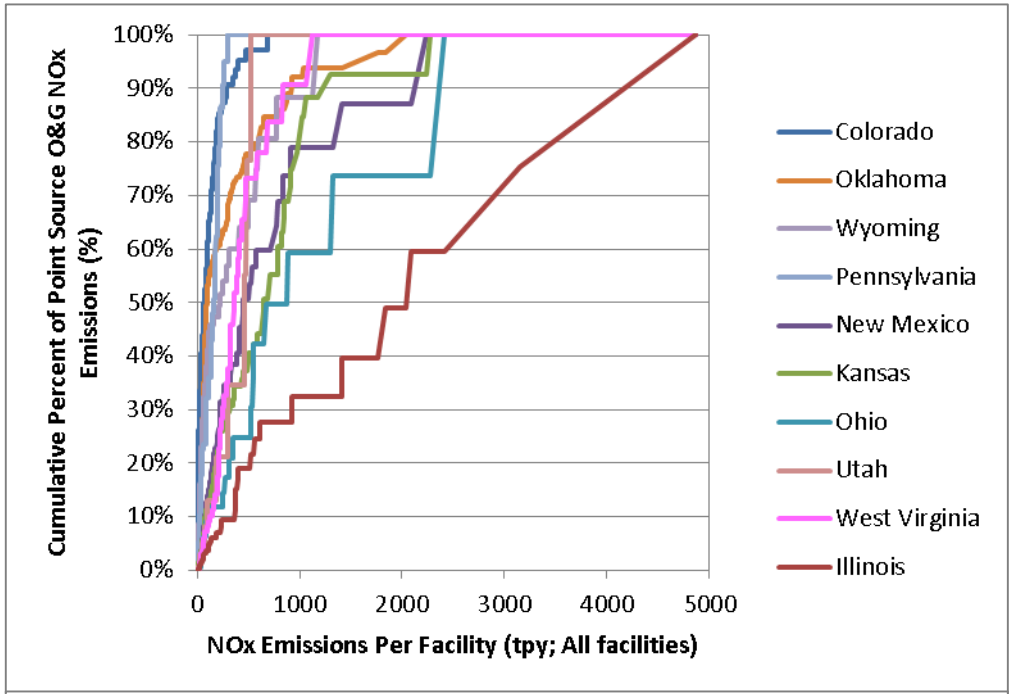
- States with low permitting thresholds (CO, OK, WY, PA) have more emissions from lower emitting facilities

  Potential Causes

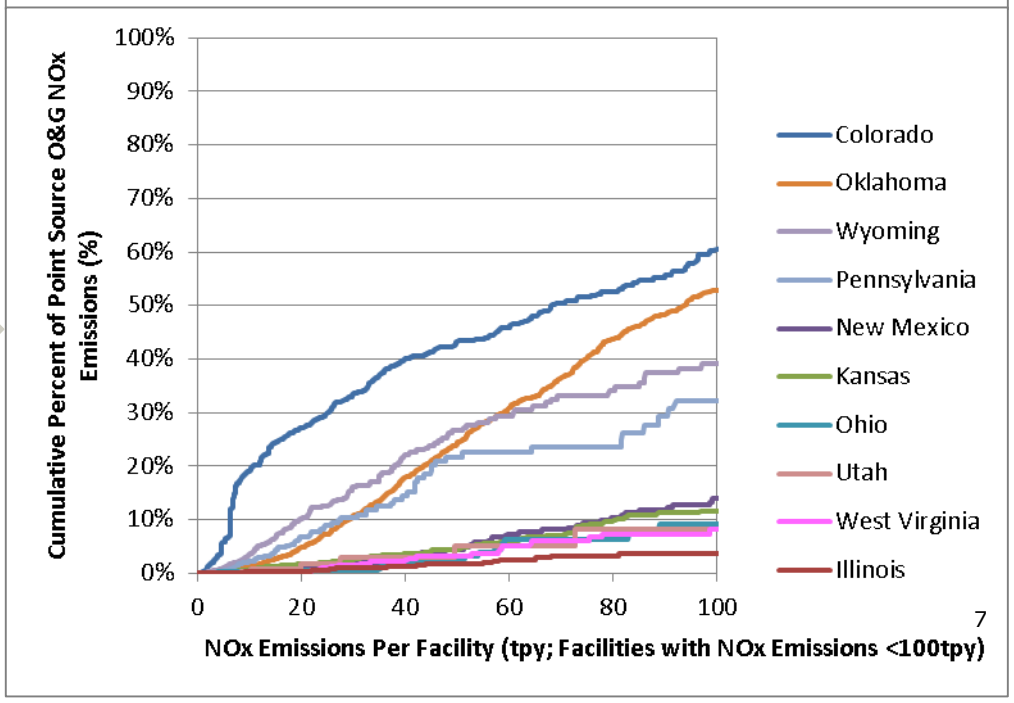
  - **Unreported facilities** for states not reporting facilities from smaller facilities (KS, NM, OH, UT, WV, IL)
  - **Skewed facility emissions** in CO, OK, WY, and PA to lower emission facilities

- Analysis of facility reporting across programs (e.g. NEI & GHGRP) could facilitate further analysis (Combined Air Emissions Reporting [CAER] project)

Cumulative Emissions by Facility
All O&G facilities



Cumulative Emissions by Facility
O&G Facilities with NOx Emissions <100tpy



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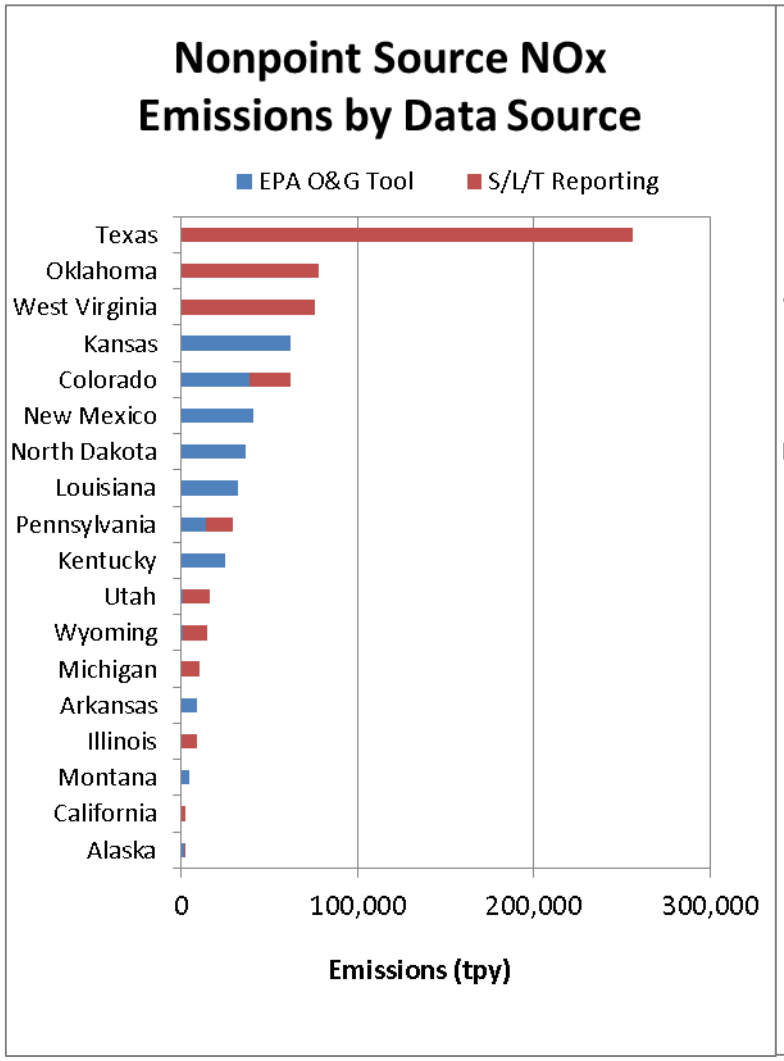
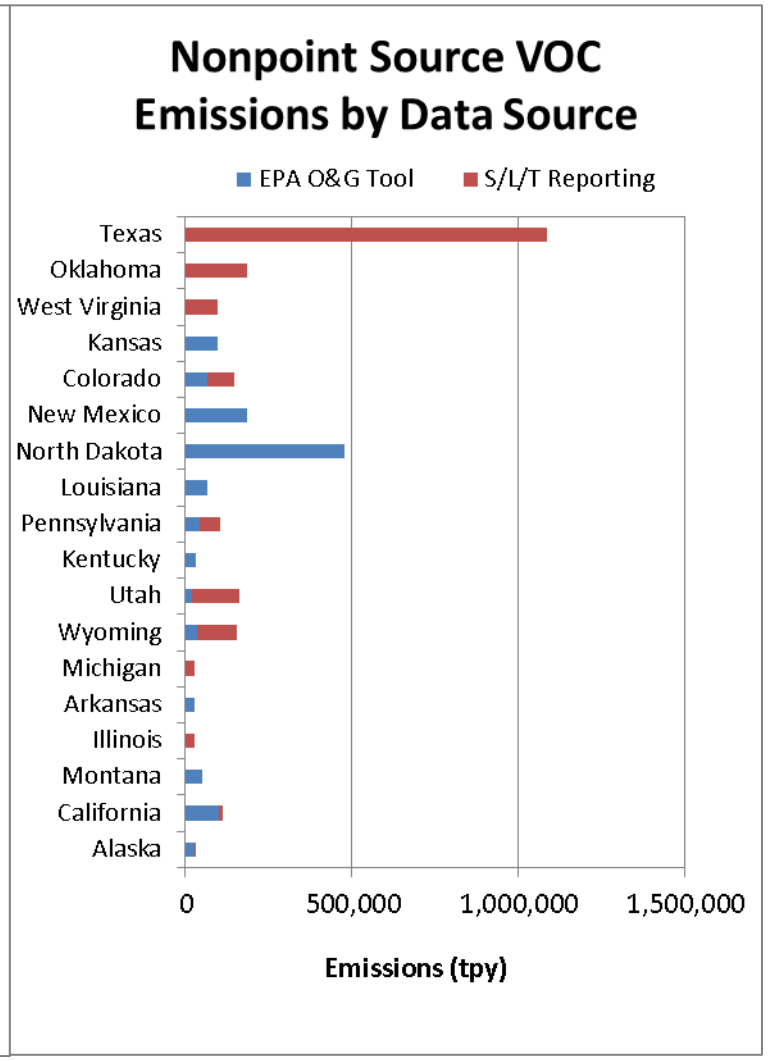
NONPOINT O&G SOURCES

- Primarily well-site sources in 2014 and previous NEIs
- Intended to capture all sources not in point sector
- Some challenges to developing complete, accurate O&G inventory
  - High emitter / fat-tail sites
  - Pipelines between wellheads and gas processing facilities
  - Small facilities downstream of well-site not reported in the point source emission inventory
- Focus of this nonpoint analysis is well-sites
  - S/L/T agency estimates
  - O&G Tool estimates

2014 NEI (V1) O&G NONPOINT NOX AND VOC EMISSIONS

- Substantial S/L/T agency reporting
- Where S/L/T agency doesn't report, O&G Tool estimates emissions





Only states with over 10,000 tpy NOx emissions or 20,000 tpy VOC emissions are shown.

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O&G ACTIVITY BY WELL TYPE

- Well type definition is important
- Several definitions:
  - O&G Tool: ≤100 MCF per barrel
  - NSPS OOOO: principal product
  - GHGRP: producing formation
  - IHS Enerdeq: state reporting database
  - State OGCC code

Source	Well Type Definition	Oil Production (Mbbl/yr)			Well Count		
		Gas Wells	Oil Wells	All Wells	Gas Wells	Oil Wells	All Wells
Colorado							
State Database	State Definition	*does not define well type*					
	100 MCF/bbl GOR	1,595	94,331	**95,926**	24,098	23,720	**47,818**
IHS Enerdeq		26,760	68,417	**95,177**	39,377	8,370	**47,747**
EPA Tool (100 MCF/bbl GOR)		2,167	92,711	**94,878**	22,746	18,898	**41,644**
Utah							
State Database[3]	State Definition	2,142	38,762	**40,903**	7,478	5,533	**13,011**
	100 MCF/bbl GOR	803	40,100	**40,903**	6,213	6,798	**13,011**
IHS Enerdeq		2,270	38,627	**40,897**	7,474	5,544	**13,018**
EPA Tool (100 MCF/bbl GOR)		812	40,988	**41,800**	5,894	5,976	**11,870**
Wyoming							
State Database[4]	State Definition	11,752	64,361	**76,113**	23,878	11,738	**35,616**
	100 MCF/bbl GOR	5,508	70,605	**76,113**	20,320	15,296	**35,616**
IHS Enerdeq		11,408	64,743	**76,151**	23,787	11,826	**35,613**
EPA Tool (100 MCF/bbl GOR)		5,622	69,765	**75,387**	18,572	13,059	**31,631**

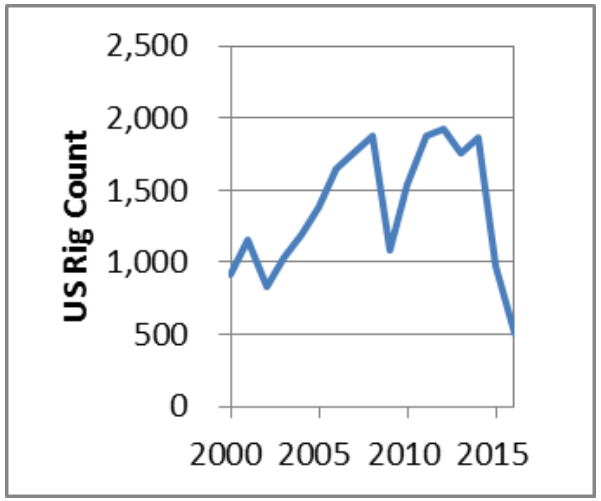
SUBPART W

- Common source of data collected across US
- 2014 Subpart W data has been incorporated into O&G Tool for several sources
- How representative is the Subpart W data?
  - Fraction of O&G activity represented?
  - Emissions regime similar for operators not reporting?

O&G TOOL DRILLING EMISSION FACTORS

Horsepower Range	EPA O&G Tool (v1.5)		Federal Tier Standards		
	NOx Emission Factor (g/hp-hr)	Basis	Tier Level	Years	NOx standard (g/hp-hr)
300-600	4.258	CenSARA (2012)	Tier 1	1996-2000	6.9
			Tier 2	2001-2005	4.8[1]
			Tier 3	2006-2010	3.0[1]
			Tier 4 (interim)	2011-2013	3.0[1]
			Tier 4 (final)	2014+	0.3
600-750	4.262	CenSARA (2012)	Tier 1	1996-2001	6.9
			Tier 2	2002-2005	4.8[1]
			Tier 3	2006-2010	3.0[1]
			Tier 4 (interim)	2011-2013	3.0[1]
>750	5.831	CenSARA (2012)	Tier 1	2000-2005	6.9
			Tier 2	2006-2010	4.8[1]
			Tier 4 (interim)	2011-2014	0.3
			Tier 4 (final)	2015+	0.14

[1] NOx+NMHC

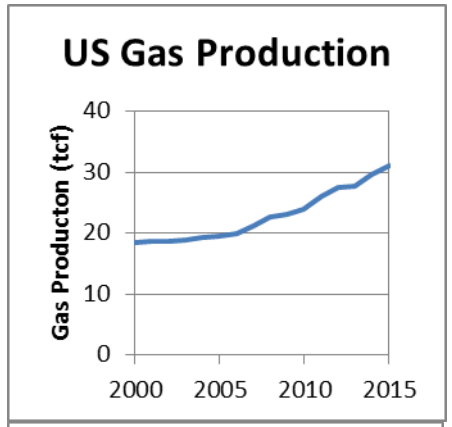


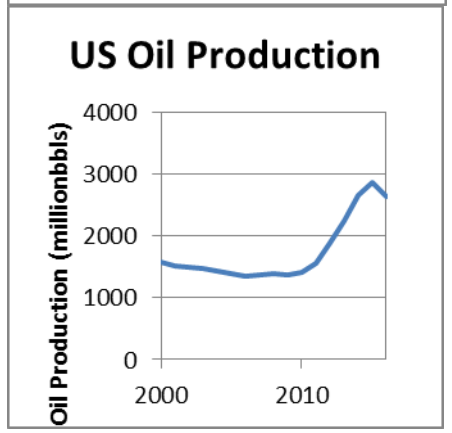
Source: Baker & Hughes

- CenSARA data is 5+ years old, *but collected after dramatic rise in rig count*
- Extent of fleet turnover unknown

O&G TOOL NATURAL GAS ENGINE EMISSION FACTORS

- CenSARA data is 5+ years old
- Substantial new production in the last five years
- NSPS JJJJ requirements should decrease average emission rate as new sources subject to final NSPS JJJJ come online
- Extent to which NSPS JJJJ provisions affect existing sources under "modified" provision unknown





Source: EIA

Engine Type	EPA O&G Tool		EPA NSPS JJJJ		
	NOx (g/hp-hr)	Basis	HP Range	Manufacture Date	NOx (g/hp-hr)
Artificial Lift Engines	8.24	CenSARA (2012)	25-100	7/1/2008	2.8
Lean Burn 2-cycle	7.04		100≤HP<500	7/1/2008, 1/1/2011	2.0, 1.0
Lean Burn 4-cycle	3.07				
Rich Burn 4-cycle	8.24 [5.9[A]]				

[A] with default control

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O&G EMISSION FORECAST CHALLENGES

- Forecasts are uncertain due to dependence of future activity on market conditions
- Capturing regional trends is challenging
- Estimating effects of state regulations is complex
  - Not enough information to estimate current level of control for existing facilities
  - S/L/T agency specific analyses require resources and regional regulation expertise
- Effects of NSPS JJJJ and OOOO "modified" provision unknown, but could be important

RECOMMENDATIONS

Sector	Recommendation
High Priority	
Point & Nonpoint	Gap fill missing non well-site O&G emission sources
Nonpoint	Align oil and gas well type definition with inventory inputs
	Remove CO_2 gas production activity from the EPA O&G Tool (COMPLETE)
	Analyze GHGRP Subpart W in O&G Tool to determine whether it can be considered representative
	Continue enhancement of EPA O&G Tool input factors
Medium Priority	
Point & Nonpoint	Account for fat-tails
	Account for state and federal programs in forecast inventories.
Point	Add an "uncontrolled" control type to Control_ID field in the NEI point source database
	Consider GHGRP pipeline emissions (reporting required from regulatory year 2016) for developing pipeline emissions in the 2017 NEI
Nonpoint	Use GHGRP Subpart W fugitive device counts, pneumatic pump counts, and compressor engine prevalence data for high level checks of Tool input factors
	Update O&G Tool emission factors
Low Priority	
Point	Distinguish NEI O&G point source emissions by O&G subsector (e.g. Production and Processing, Natural Gas Transmission and Storage, and Distribution)
	Enhance the synergies between the NEI and GHGRP Subpart W through common naming and/or facility, unit, and process identifiers
Nonpoint	Add emissions to the O&G Tool for water pump engines, workover rigs, injection pump blowdowns, hydrocarbon liquids dissolved CO2, and well testing venting emission source categories

ONGOING WORK

- Regional studies – basin specific analyses for several issues identified in National Analysis
  - Marcellus Basin (PA)
  - Utica Basin (OH)
  - Green River Basin (WY)
  - Anadarko Basin (OK)
  - San Juan Basin (NM)
- Basin specific analysis scopes available: https://www.wrapair2.org/NatOilGas.aspx
- Expected release of study results in early-Fall, 2017

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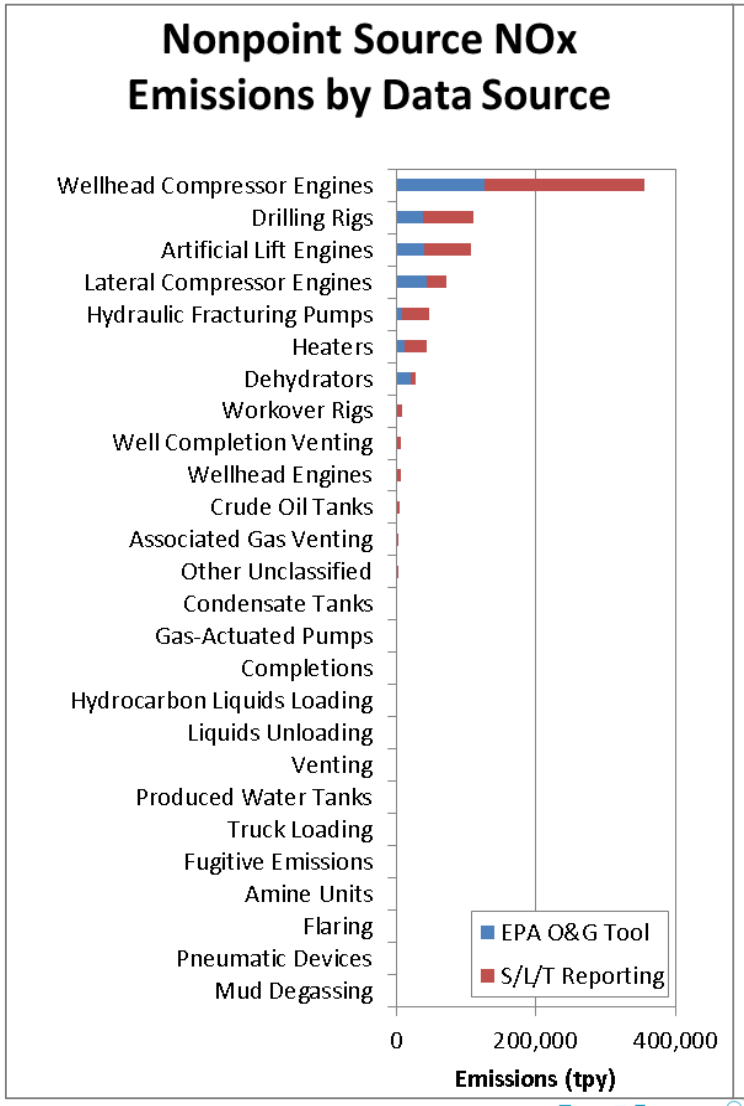
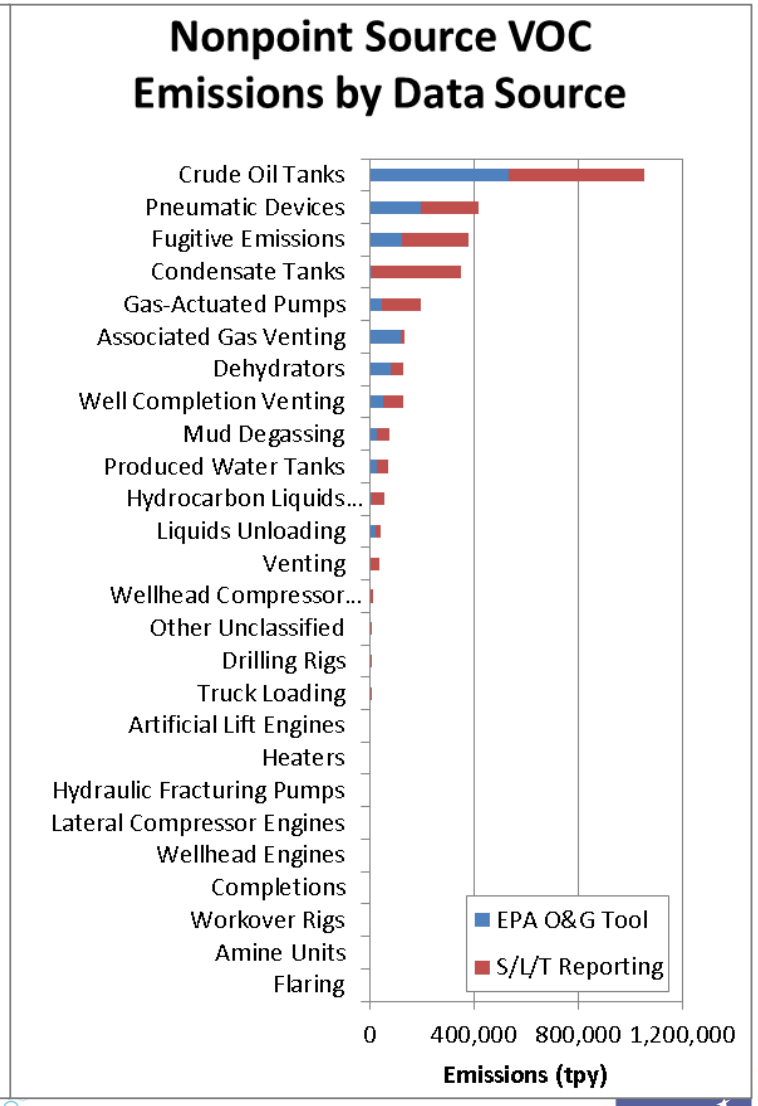
2014 NEI (V1) O&G NONPOINT NOX AND VOC EMISSIONS





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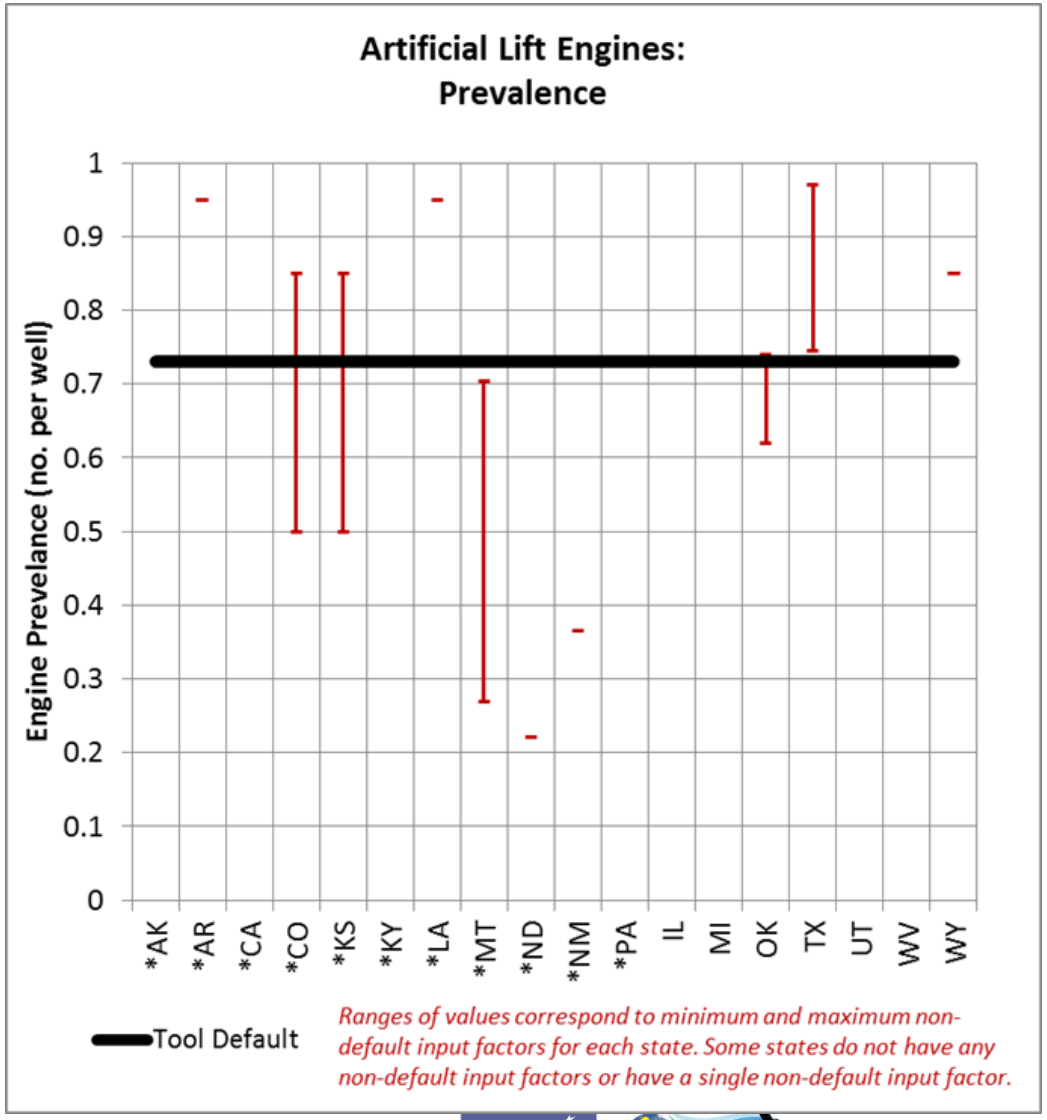
O&G TOOL BASIN FACTOR INPUT EXAMPLE

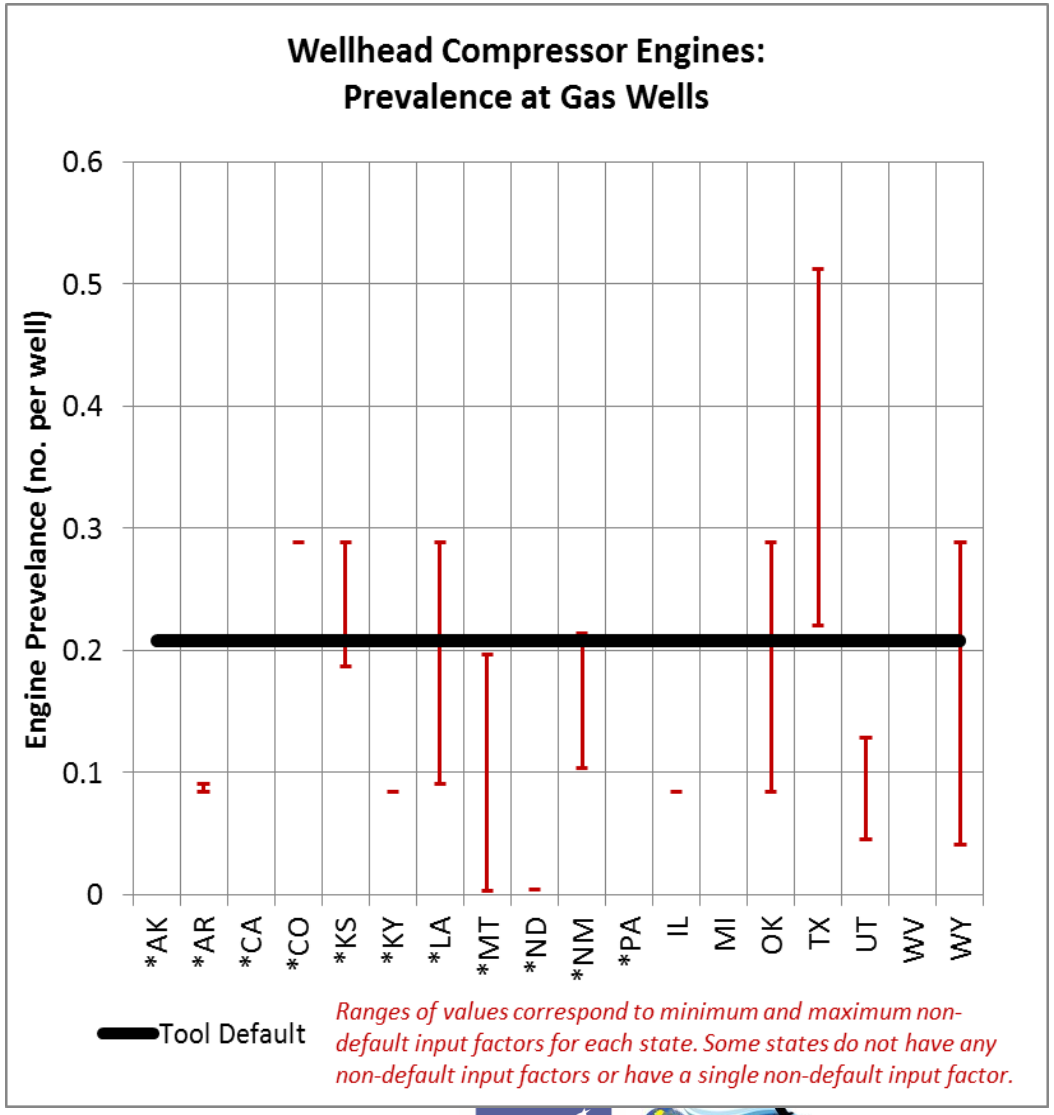
- **Artificial lift engine prevalence**
- Default: 73%.
  - All O&G basins in Alaska, California, Kentucky, Pennsylvania, Illinois, Michigan, Utah, and West Virginia rely solely on default estimates.
- Update priority: High priority for states in which 2014 NEI emissions are based on the EPA O&G Tool artificial lift engine emissions (e.g. Kentucky, Alaska, Utah), low priority elsewhere.
  - Substantial input factor variation by basin.
  - Artificial lift engines are a substantial source of NOx emissions.



RAMBOLL ENVIRON Aether WESTAR WRAP

O&G TOOL BASIN FACTOR INPUT EXAMPLE

- **Wellhead compressor engine prevalence**
- Default: 21%. All O&G basins in Alaska, California, Pennsylvania, Michigan, and West Virginia rely solely on default estimates.
- Update priority: High priority for states in which 2014 NEI emissions are based on the EPA O&G Tool wellhead compressor engine emissions (e.g. Kentucky, Alaska), low priority elsewhere.
  - Substantial input factor variation by basin.
  - Wellhead compressor engines are a substantial source of NOx emissions.



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