



# 2020 Nonpoint Oil and Gas Emission Estimation Tool Version 1.1

Prepared for:

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## **1.0 INTRODUCTION**

### **1.1 The National Emissions Inventory (NEI)**

The U.S. Environmental Protection Agency's (EPA) Emission Inventory and Analysis Group (EIAG) produces the National Emission Inventory (NEI) for criteria and hazardous air pollutants (HAPs) every three years. The NEI is a comprehensive and detailed estimate of air emissions of both criteria and HAP from all air emissions sources, including both stationary (e.g. power plants and petroleum refineries) and mobile (e.g. automobiles and aircraft) sources. The NEI is prepared by the U.S. EPA based primarily upon emission estimates and emission model inputs provided by State, Local, and Tribal air agencies for sources in their jurisdictions, and supplemented by data developed by the U.S. EPA. These data are needed for a variety of reasons, including modeling demonstrations, regulatory analyses, and to produce the National Air Pollutant Emission Trends report.

Emissions from stationary sources can be divided into two sectors: point sources and nonpoint sources (nonpoint sources are sometimes referred to as area sources). The NEI point sources emissions inventory contains emissions estimates for sources that are individually inventoried and usually located at a fixed, stationary location, although portable sources such as some asphalt or rock crushing operations are also included. Point sources include large industrial facilities and electric power plants, but also increasingly include many smaller industrial and commercial facilities, such as dry cleaners and gas stations, which have traditionally been included as nonpoint sources.

The NEI nonpoint sources emissions inventory includes emission sources which individually are too small in magnitude or too numerous to inventory as individual point sources, and which can often be estimated more accurately as a single aggregate source for a County or Tribal area. Examples of nonpoint source categories are residential heating and consumer solvent use.

The 2020 NEI is currently being developed and will utilize the emission estimates generated by the 2020 Nonpoint Oil and Gas Emission Estimation Tool (the "tool") as described in Section 1.2. For historical reference, the 2011, 2014, and 2017 NEI and supporting documentation is available on-line at <https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei>.

### **1.2 Nonpoint Oil and Gas Emission Estimation Tool**

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; the Permian Basin in Texas and New Mexico; and the Bakken Shale/Williston Basin in North Dakota and Montana have all experienced a rapid

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expansion in activity over the last ten 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 this 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 (see Section 3.11).

While the major emissions sources associated with oil and gas collection, processing, and distribution have traditionally been included in the 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 report, 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.

The NEI nonpoint oil and gas emissions inventory is primarily developed using data supplied to EPA by state air agencies. Where state data is not supplied to EPA, EPA populates the NEI with the best available data. In the case of nonpoint oil and gas emissions estimates, EPA has developed the tool described in this report to estimate emissions from this category. 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 emission estimates generated by the tool are only used in the NEI if state data is not available. Where state data is available but does not include HAP, EPA estimates HAPs based on their ratios to VOC or PM in gas composition profiles and adds them to the NEI. The HAP augmentation procedure is described in detail in the documentation for the 2014 NEI (<https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data>).

This report describes the technical approach used to develop the tool to characterize emissions from nonpoint oil and gas exploration and production sources for the year 2020. The tool generates estimates of emissions of oxides of nitrogen (NO<sub>x</sub>), volatile organic compounds (VOC), particulate matter (PM), carbon monoxide (CO), ammonia (NH<sub>3</sub>), sulfur dioxide (SO<sub>2</sub>), HAPs, and hydrogen sulfide (H<sub>2</sub>S) from upstream oil and gas production activities. Specific source categories included in the tool are:

- Artificial Lift Engines
- Associated Gas Venting
- Coalbed Methane Dewatering Pump Engines
- Condensate Tanks
- Crude Oil Tanks
- Dehydrators

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- Drilling Rigs
- Fugitive Emissions
- Gas-Actuated Pneumatic Pumps
- Heaters
- Hydraulic Fracturing Pumps
- Lateral Compressor Engines
- Liquids Unloading
- Hydrocarbon Liquids Loading
- Mud Degassing
- Pneumatic Devices
- Produced Water Tanks
- Well Completion Venting
- Wellhead Compressor Engines
- Flaring (when used to control emissions from the unit processes listed above)

Many of the source categories covered by the tool are further sub-divided into distinct source classification codes (SCCs) specific to either a well type (gas or oil), a sub-category of the broader equipment type (such as fugitive emissions from connectors and fugitive emissions from valves), or some other distinction. Table 1-1 presents a complete listing of the SCCs covered by the tool for each of the source categories listed above.

**Table 1-1. SCC Listing**

Source Category	SCC	SCC Description
Artificial Lift Engines	2310011600	Oil and Gas: Onshore Oil Production/Artificial Lift Engines
Associated Gas Venting	2310011001	Oil and Gas: Onshore Oil Production/Associated Gas Venting
CBM Dewatering Pump Engines	2310023000	Coal Bed Methane NG/Dewatering Pump Engines
Condensate Tanks	2310021010	On-Shore Gas Production /Storage Tanks: Condensate
Condensate Tanks	2310023010	On-Shore CBM Production /Storage Tanks: Condensate
Crude Oil Tanks	2310010200	Oil & Gas Expl & Prod /Crude Petroleum /Oil Well Tanks - Flashing & Standing/Working/Breathing
Dehydrators	2310021400	On-Shore Gas Production Dehydrators
Dehydrators	2310023400	Coal Bed Methane NG / Dehydrators
Drilling Rigs	2310000220	Oil And Gas Exploration Drill Rigs
Fugitive Emissions	2310011501	On-Shore Oil Production /Fugitives: Connectors
Fugitive Emissions	2310011502	On-Shore Oil Production /Fugitives: Flanges
Fugitive Emissions	2310011503	On-Shore Oil Production /Fugitives: Open Ended Lines

**Nonpoint Oil and Gas Emissions Estimation Tool****Table 1-1. SCC Listing**

Source Category	SCC	SCC Description
Fugitive Emissions	2310011505	On-Shore Oil Production /Fugitives: Valves
Fugitive Emissions	2310021501	On-Shore Gas Production /Fugitives: Connectors
Fugitive Emissions	2310021502	On-Shore Gas Production /Fugitives: Flanges
Fugitive Emissions	2310021503	On-Shore Gas Production /Fugitives: Open Ended Lines
Fugitive Emissions	2310021505	On-Shore Gas Production /Fugitives: Valves
Fugitive Emissions	2310021506	On-Shore Gas Production /Fugitives: Other <sup>a</sup>
Fugitive Emissions	2310023511	On-Shore CBM Production /Fugitives: Connectors
Fugitive Emissions	2310023512	On-Shore CBM Production /Fugitives: Flanges
Fugitive Emissions	2310023513	On-Shore CBM Production /Fugitives: Open Ended Lines
Fugitive Emissions	2310023515	On-Shore CBM Production /Fugitives: Valves
Fugitive Emissions	2310023516	On-Shore CBM Production /Fugitives: Other <sup>a</sup>
Gas-Actuated Pumps	2310023310	Coal Bed Methane NG / Pneumatic Pumps
Gas-Actuated Pumps	2310111401	On-Shore Oil Exploration /Oil Well Pneumatic Pumps
Gas-Actuated Pumps	2310121401	On-Shore Gas Exploration: Gas Well Pneumatic Pumps
Heaters	2310010100	On-Shore Oil Production /Heater Treater
Heaters	2310021100	On-Shore Gas Production /Gas Well Heaters
Heaters	2310023100	On-Shore CBM Production /CBM Well Heaters
Hydraulic Fracturing Pumps	2310000660	Oil & Gas Expl & Prod /All Processes /Hydraulic Fracturing Engines
Hydrocarbon Liquids Loading	2310011201	On-Shore Oil Production /Tank Truck/Railcar Loading: Crude Oil
Hydrocarbon Liquids Loading	2310021030	On-Shore Gas Production /Tank Truck/Railcar Loading: Condensate
Hydrocarbon Liquids Loading	2310023030	On-Shore CBM Production /Tank Truck/Railcar Loading: Condensate
Lateral Compressor Engines	2310021251	On-Shore Gas Production/Lateral Compressors 4 Cycle Lean Burn
Lateral Compressor Engines	2310021351	On-Shore Gas Production/Lateral Compressors 4 Cycle Rich Burn
Lateral Compressor Engines	2310023251	On-Shore CBM Production/Lateral Compressors 4 Cycle Lean Burn
Lateral Compressor Engines	2310023351	On-Shore CBM Production/Lateral Compressors 4 Cycle Rich Burn
Liquids Unloading	2310021603	On-Shore Gas Production / Gas Well Venting - Blowdowns

**Table 1-1. SCC Listing**

Source Category	SCC	SCC Description
Liquids Unloading	2310023603	On-Shore CBM Production / CBM Well Venting - Blowdowns
Mud Degassing	2310023606	On-Shore CBM Exploration /Mud Degassing
Mud Degassing	2310111100	On-Shore Oil Exploration /Mud Degassing
Mud Degassing	2310121100	On-Shore Gas Exploration /Mud Degassing
Pneumatic Devices	2310010300	Oil Production Pneumatic Devices
Pneumatic Devices	2310021300	On-Shore Gas Production Pneumatic Devices
Pneumatic Devices	2310023300	On-Shore CBM Production Pneumatic Devices
Produced Water Tanks	2310000551	Produced Water from CBM Wells
Produced Water Tanks	2310000552	Produced Water from Gas Wells
Produced Water Tanks	2310000553	Produced Water from Oil Wells
Well Completion Venting	2310023600	On-Shore CBM Exploration: CBM Well Completion: All Processes
Well Completion Venting	2310111700	On-Shore Oil Exploration: Oil Well Completion: All Processes
Well Completion Venting	2310121700	On-Shore Gas Exploration: Gas Well Completion: All Processes
Wellhead Compressor Engines	2310021102	On-Shore Gas Production /Natural Gas Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP
Wellhead Compressor Engines	2310021202	On-Shore Gas Production /Natural Gas Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP
Wellhead Compressor Engines	2310021302	On-Shore Gas Production /Natural Gas Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP
Wellhead Compressor Engines	2310023102	On-Shore CBM Production /CBM Fired 2Cycle Lean Burn Compressor Engines 50 To 499 HP
Wellhead Compressor Engines	2310023202	On-Shore CBM Production /CBM Fired 4Cycle Lean Burn Compressor Engines 50 To 499 HP
Wellhead Compressor Engines	2310023302	On-Shore CBM Production /CBM Fired 4Cycle Rich Burn Compressor Engines 50 To 499 HP

<sup>a</sup> This SCC used for compressor seal leaks.

It should be noted that these source categories do not represent a complete list of all emission sources or SCCs that may be found at upstream oil and gas exploration and production sites. However, the most significant nonpoint sources that contribute to emissions have been included. Sources that were not included due to limited data availability include: salt water injection engines, well pad construction equipment, workover equipment, and mobile sources. Associated on-road mobile sources operating in the field, such as service vehicles used during construction, drilling and production phases, may be included in some states' mobile source emissions inventories but are not specifically included in the tool.

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ERG developed the tool initially under EPA Contract No. EP-D-11-006, Work Assignment (WA) 2-05, followed on by subsequent WAs and this Task Order (TO). The purpose/objectives of the WAs/TO were the following:

- 1) Develop a nonpoint methodology to estimate county-level emissions of criteria pollutants and HAP for the upstream oil and gas production sector for 2011, 2014, 2017, and 2020;
- 2) Implement the methodology to develop county-level emissions inventories for this sector; and
- 3) Develop a MS Access-based tool incorporating the methodologies and available information that may be used by EPA, states, and local agencies to develop state or region-specific emission inventories for the upstream oil and gas sector based on user supplied activity and emissions inputs.

The following describes how the information in this report is organized:

Section 2 – background information on development of tool

Section 3 – information on the methodology and emission estimation approach used for each source category

Section 4 – summary of nonpoint oil and gas emission estimates generated by the tool

Section 5 – summary of nonpoint oil and gas emission estimates in the 2020 NEI

Section 6 – recommended future activities for improving nonpoint oil and gas emission inventories

### **Note on greenhouse gas (GHG) emissions**

EPA GHG emissions estimates for oil and gas are available at the national level (GHG Inventory, <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html>) and facility-level (Greenhouse Gas Reporting Program, <http://www.epa.gov/ghgreporting/>).

While GHG emissions are not the focus of this tool, they are used in the tool in some places as necessary intermediary steps in the calculation of other pollutants.

## **2.0 BACKGROUND ON DEVELOPMENT OF THE TOOL**

The tool was developed based on work that has been done in this sector over the last several years by various states, inter-governmental agencies, and EPA. These efforts include work done by the Texas Commission on Environmental Quality (TCEQ), the Western Regional Air Partnership (WRAP), and the Central States Air Resource Agencies (CenSARA) to develop improved nonpoint oil and gas emissions inventories.

In 2010, the seven CenSARA states (Texas, Louisiana, Oklahoma, Arkansas, Kansas, Missouri and Nebraska) had a combined oil production of approximately 611 million barrels and a combined gas production of 12.8 trillion cubic feet, representing 48 % of total gas production and 31% of total oil production in the country, including both conventional and unconventional resource plays.<sup>1</sup> As such, the CenSARA inventory effort covered a wide variety of processes and well types and was used as the starting point for the tool. In particular, the Excel-based emission estimation tool that was developed for the CenSARA study was used as the basis for initial development of the tool described in this report. Subsequent updates to the tool incorporated data from numerous additional sources, including the TCEQ and WRAP data mentioned above, related EPA inventory efforts, and data provided to EPA directly from state air agencies.

The basic methodology used to develop the CenSARA inventory was also used to develop the tool and consisted of the following steps:

- Compile activity data - Oil and gas activity data was obtained to include, but is not limited to, the number of active wells by well type, gas production and oil production, spud counts, feet drilled, and water production. The activity data for the tool was primarily obtained from the Enverus database, a commercial database that processes state-level oil and gas commission data into a comprehensive database of production statistics. Data used in this version of the tool is for the calendar year 2020 and is based on Enverus data as of September 14, 2021. As described further in section 2.1, EPA uses other activity data that is not available in Enverus for certain states.
- Compile process characterization and emission factor data - To initially populate the tool, process characterization data and emissions factors from the CenSARA study were used for the counties in the CenSARA states, and an average of the data for the CenSARA basins were used for the remainder of the counties in the country. Under the CenSARA study, these data were developed or collected from a variety of sources including: 1) oil and gas operator surveys, 2) state minor source permit applications, and 3) literature review. Emission factors for combustion equipment has primarily been taken from AP-42. Much of the initial CenSARA process characterization data used to populate the tool database has since been replaced, as described below in more detail. For example, EPA GHG Reporting Program data (Subpart W) were used

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<sup>1</sup> Internet address: <http://www.eia.gov/>



## **Nonpoint Oil and Gas Emissions Estimation Tool**

to develop default values for several categories, including condensate tanks, crude oil tanks, pneumatic devices, and heaters.<sup>2</sup>

- Incorporate updated process characterization data - Several state and local air quality agencies and Regional Planning Organizations (RPOs) provided updates to replace the default CenSARA and EPA process characterization data. The tool database contains reference information identifying the source of all inputs into the estimates.
- Develop Access-based tool to house the inventory - A Microsoft Access-based tool that estimates 2020 nonpoint oil and gas emissions at the county level was then developed using the compiled activity and process characterization data. The tool has been programmed to be flexible and allow for user-specified inputs such that users may update activity and emissions data at the basin and/or county level for future use. Additional details on the tool and user's instructions are included in Appendices A (Exploration Module) and B (Production Module).

Finally, the tool has been programmed to facilitate NEI submissions by generating EPA Emission Inventory System (EIS) staging tables. These tables can be converted into valid XML files that are in compliance with the EPA-supplied Consolidated Emissions Reporting Schema (CERS) using an EPA-supplied XML File Generator tool. Therefore, the tool allows users to both generate the oil and gas emissions and format them for NEI submission.

### **2.1 Activity Data**

Activity data were obtained at the county level for the entire country to include the key activity parameters that affect emissions. These key activity factors include, but are not limited to, the number of active wells by well type, gas production and oil production by well type, spud count, estimated feet (depth) drilled by wellbore type, and water production by well type. Activity data for the 2020 base year were obtained from the Enverus database, RIGDATA,<sup>3</sup> state oil and gas commission websites, and directly from state and local agencies involved in development and review of the tool.

Table 2-1 presents the activity data parameters used in the tool to calculate emissions.

**Table 2-1. Activity Parameters Needed to Estimate Emissions**

<b>Data Parameter</b>
Oil Production (barrels or BBL)
Natural Gas Production (thousand standard cubic feet or MCF)
CBM Production (thousand standard cubic feet or MCF)

<sup>2</sup> "Summary of Analysis of 2020 GHGRP Subpart W Data for Use in the 2020 NEI Nonpoint Oil and Gas Emission Estimation Tool", Memorandum from Mike Pring and Stephen Treimel to Jeff Vukovich and Jennifer Snyder. December 3, 2021.

<sup>3</sup> U.S. Well Starts By Depth Range, January 2020 through December 2020. Used by Permission and Approved for Publication by Hom Rana at RIGDATA ([www.rigdata.com](http://www.rigdata.com)) in e-mail communication to Regi Oommen, Eastern Research Group, Inc. April 21, 2021.



**Table 2-1. Activity Parameters Needed to Estimate Emissions**

<b>Data Parameter</b>
Condensate Production (BBL)
Associated Gas Production (MCF)
Oil Well Counts
Natural Gas Well Counts
CBM Well Counts
Oil Well Completions (Conventional and Unconventional)
Natural Gas Well Completions (Conventional and Unconventional)
CBM Well Completions (Conventional and Unconventional)
Produced Water Production at Oil Wells (BBL)
Produced Water Production at Gas/CBM Wells (BBL)
Spud Counts (Vertical, Horizontal, Directional)
Feet Drilled (Vertical, Horizontal, Directional)

Table 2-2 presents the activity parameter data sources for each state for the data types identified in Table 2-1.

**Table 2-2. Activity Parameter Data Sources by State**

<b>State</b>	<b>Oil/ Associated Gas Production</b>	<b>Natural Gas/ Condensate Production</b>	<b>CBM Gas/ Condensate Production</b>	<b>Produced Water</b>	<b>Well Completions</b>	<b>Spud Counts/ Feet Drilled</b>
Alabama	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ AL OGC 2021
Alaska	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Arizona	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Arkansas	2021 ENVERUS/ AROGC 2021	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ AROGC 2021	2021 ENVERUS/ AROGC 2021	2021 ENVERUS
California	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Colorado	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ CO OGC	2021 ENVERUS/ CO OGC

**Table 2-2. Activity Parameter Data Sources by State**

<b>State</b>	<b>Oil/ Associated Gas Production</b>	<b>Natural Gas/ Condensate Production</b>	<b>CBM Gas/ Condensate Production</b>	<b>Produced Water</b>	<b>Well Completions</b>	<b>Spud Counts/ Feet Drilled</b>
Florida	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	FL DEP/ RIGDATA
Idaho	ID OGC 2021	ID OGC 2021	ID OGC 2021	ID OGC 2021	ID OGC 2021	ID OGC 2021
Illinois	2019 ILOGC CF	2019 EIA CF	2019 EIA CF	CALC_RATIO	IL OGC 2021	IL OGC 2021/ RIGDATA
Indiana	IN OGC 2021	IN OGC 2021	IN OGC 2021	CALC_RATIO	IN OGC 2021	IN OGC 2021
Kansas	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	KS OGC	2021 ENVERUS/ KS OGC 2021	2021 ENVERUS/ KS OGC 2021
Kentucky	2019 KYDEP CF	2019 KYDEP CF	2021 ENVERUS	CALC_RATIO	KY DEP 2021	KY DEP 2021
Louisiana	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ CALC_RATIO	2021 ENVERUS	2021 ENVERUS
Maryland	EIA 2021	EIA 2021	EIA 2021	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Michigan	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ MI OGC 2021	2021 ENVERUS
Mississippi	MS OGC 2021	MS OGC 2021	2021 ENVERUS	MS OGC 2021	2021 ENVERUS	MS OGC 2021
Missouri	MO DNR 2021	MO DNR 2021	2021 ENVERUS	MO DNR 2021	2021 ENVERUS	MO OGC 2021
Montana	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Nebraska	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ NE OGC 2021	NE OGC 2021/ RIGDATA
Nevada	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
New Mexico	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ NM OGC 2021
New York	NY OGC 2021	NY OGC 2021	2021 ENVERUS	2021 ENVERUS/ NY OGC 2021	2021 ENVERUS/ NY OGC 2021	2021 ENVERUS/ NY OGC 2021

**Table 2-2. Activity Parameter Data Sources by State**

<b>State</b>	<b>Oil/ Associated Gas Production</b>	<b>Natural Gas/ Condensate Production</b>	<b>CBM Gas/ Condensate Production</b>	<b>Produced Water</b>	<b>Well Completions</b>	<b>Spud Counts/ Feet Drilled</b>
North Dakota	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Ohio	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Oklahoma	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	CALC_RATIO	2021 ENVERUS/ OK DEQ 2021	2021 ENVERUS/ OK DEQ 2021
Oregon	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Pennsylvania	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	PA DEP 2021	2021 ENVERUS	2021 ENVERUS
South Dakota	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Tennessee	2021 EIA	2021 EIA	2021 EIA	CALC_RATIO	TN OGC 2021	RIGDATA
Texas	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ CALC_RATIO	2021 ENVERUS	2021 ENVERUS
Utah	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Virginia	2021 ENVERUS	VADEQ 2021	VADEQ 2021	CALC_RATIO	2021 ENVERUS	2021 ENVERUS/ VA OGC 2021
West Virginia	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS
Wyoming	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS	2021 ENVERUS/ WY OGC 2021	2021 ENVERUS/ WY OGC 2021

### **2.1.1 ENVERUS Data**

The primary data source for obtaining activity data was Enverus' HPDI database (HPDI). This subscription-based information service extracts well-level data from state oil and gas commission websites and prepares it in a standardized format. As part of EPA's Enforcement Activities, EPA has an annual subscription to Enverus, allowing data downloads, or "refreshes," to be obtained throughout the year. In accordance with the EPA's licensing agreement, well-level data is proprietary, but derived products, such as aggregation at the county-level, are acceptable for public dissemination and use in the tool.

**Nonpoint Oil and Gas Emissions Estimation Tool**

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ERG extracted well identification and production information for onshore wells and leases. Table 2-3 provides details on the available data by state, as of the September 2021 refresh. Table 2-3 also includes the update frequency of the data by state and provides the date of the latest production data included in the September 2021 refresh.

**Table 2-3. Enverus Data Coverage by State**

<b>State Abbreviation</b>	<b>Production Group</b>	<b>Update Frequency</b>	<b>Latest Production Data</b>
Alabama	Well	Monthly	May, 2021
Alaska	Well	Monthly	June, 2021
Arizona	Well	Monthly	May, 2021
Arkansas	Well	Monthly	May, 2021
California	Well	Monthly	May, 2021
Colorado	Well	Weekly	June, 2021
Florida	Well	Monthly	June, 2021
Kansas	Lease	Monthly	May, 2021
Kentucky	Well	Yearly	December, 2019
Louisiana	Well/Unit <sup>a</sup>	Monthly	June, 2021
Maryland	Well	Semi-annually	December, 2015
Michigan	Lease	Monthly	December, 2020
Mississippi	Well	Monthly	January, 2021
Missouri	Well	Bi-Monthly	June, 2019
Montana	Well	Monthly	May, 2021
Nebraska	Well	Monthly	June, 2021
Nevada	Well	Bi-Monthly	April, 2021
New Mexico	Well	Weekly	June, 2021
New York	Well	Yearly	December, 2020
North Dakota	Well	Weekly	June, 2021
Ohio	Well	Monthly/Yearly <sup>b</sup>	March, 2021
Oklahoma	Well	Monthly	May, 2021
Oregon	Well	Yearly	December, 2020
Pennsylvania	Well	Monthly/Yearly <sup>b</sup>	June, 2021
South Dakota	Well	Monthly	May, 2021
Tennessee	Lease	Yearly	December, 2016
Texas	Oil Lease/Gas Well	Twice monthly	June, 2021
Utah	Well	Monthly	June, 2021
Virginia	Well	Monthly	April, 2021
West Virginia	Well	Yearly/Quarterly <sup>c</sup>	March, 2021
Wyoming	Well	Weekly	June, 2021

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- <sup>a</sup> Louisiana Department of Natural Resources defines a unit as the “surface area that encompasses part of or the entirety of a reservoir.”
- <sup>b</sup> For Ohio and Pennsylvania, production data for conventional wells are updated annually, while production data for unconventional wells are updated monthly.
- <sup>c</sup> For West Virginia, production data for conventional wells are reported annually while production data for unconventional wells are reported quarterly.

ERG imported all of the data from HPDI into an Oracle database for pre-processing. The Oracle database combines and processes all of the download files into one table of all production wells for the EPA Enforcement Universe Database. The processing steps are discussed below.

- 1) *Combine Monthly Production and Descriptive Information*: For each entity,<sup>4</sup> ERG combined the monthly production with the descriptive information (e.g., API number, lease name, location, operator, completion date, spud date, latest production date) from the HPDIHeader table to create the Wells table for the EPA Enforcement Universe Database.
- 2) *Remove Duplicate Wells*: HPDI includes duplicate information for wells in some states because the data are stored by completion zone rather than at the well or lease level. Because all of the other descriptive data in HPDI are at the well or lease level, ERG combined duplicate API numbers (i.e., well bore identifiers<sup>5</sup>) into a single record to avoid overcounting wells. ERG excluded the records with missing API numbers (i.e., API\_NO is null) from this “remove duplicate well” step. This could result in some over counting of wells, but this should be minimal because a limited number of wells/leases did not have API numbers and there were a small percentage of duplicate wells identified.<sup>6</sup>
- 3) *Create Updated Active Status Flag (ACTIVE\_FLAG)*: ERG created an updated active status flag (ACTIVE\_FLAG) per month using the latest production date (LAST\_PROD\_DATE) after determining that HPDI’s status flag (STATUS) was not always accurate as part of the 2011 version of the Universe Database.<sup>7</sup>
- 4) *Create Monthly Production Flags*: ERG created production flags to identify miscellaneous well types (e.g., injection, observation, abandoned, pressure maintenance, N/A) that have monthly oil and gas production in 2020 (PROD\_01\_20\_FLAG through PROD\_12\_20). The production flag is “Yes” if the monthly oil or gas production is greater than zero.
- 5) *Assign Each Well as Oil, Gas, or CBM*: Each well was reviewed to determine whether it should be labeled as an oil, gas, or CBM well. As such, the following hierarchy was used:

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<sup>4</sup> HPDI assigns a unique number to each property (i.e., lease, well, unit) in the ENTITY\_ID field.

<sup>5</sup> API numbers are up to 14 digits long and are broken into four segments. The first two digits correspond to the state; the next three digits correspond to the county in the state. The next five digits are the unique well identifier for the county. The next two digits are for the directional side tracks (i.e., horizontal or directional drills that each have different bottom hole locations), with 00 representing the original well bore. The last two digits are the event sequence code that distinguish between original completion, reentries, recompletion, and hole deepenings. Some states do not assign directional side tracks or event sequence codes.

<sup>6</sup> Duplicate wells in states with missing API numbers could be identified using the permit number, which should be unique for each well.

<sup>7</sup> ERG found some wells with an “Active” STATUS had not produced in a number of years, while some wells with an “Inactive” STATUS had production data for 2010.

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- a. Enverus designations of CBM;
  - b. Wells that had 2020 oil production, but no 2020 natural gas production were assigned as “oil” wells;
  - c. Wells that had 2020 gas production, but no 2020 oil production were assigned as “gas” wells; and
  - d. Wells that had both 2020 oil and gas production were assigned “gas” if the ratio of gas to oil was greater than 100 MCF per barrel, and were assigned “oil” if the ratio of gas to oil was less than 100 MCF per barrel.
- 6) *Calculate Well Counts:* Counting wells which produced oil, gas, or CBM and summing to the county-level will likely overestimate the number of wells which actually operated for an entire year because wells that operated for only one month would be essentially used as inputs for emission profiles assuming a year of operations for certain source categories. To account for this, monthly well counts were averaged to develop an annual average, and these averages were populated in the tool as:
- a. NONPOINT\_OIL\_WELL\_COUNT
  - b. NONPOINT\_GAS\_WELL\_COUNT, and
  - c. NONPOINT\_CBM\_WELL\_COUNT

With the exception of “Oil (and Condensate) Production” and “Feet Drilled,” all of the data parameters shown in Table 2-1 are reported fields in Enverus. Enverus reports total hydrocarbon liquids production for each well, but does not always distinguish between oil and condensate. As described above, each well was designated as either a gas well or an oil well. Liquid hydrocarbons produced at gas wells were then considered to be condensate, and liquid hydrocarbons produced at oil wells were considered to be oil.

Feet drilled and spud counts are needed for the Drilling and Mud Degassing source categories. While Enverus reports spud date and well depth for each well through RIGDATA, that information is often lagging or may be incomplete at the time of the data retrieval. Thus, EPA developed an approach for utilizing the well-specific data from Enverus and state websites and from state-level “Well Starts” and “Feet Drilled” published by RIGDATA.<sup>3</sup> The approach is as follows:

- 1) RIGDATA published total “well starts” and “feet drilled” for 28 states:

Alabama	Florida	Louisiana	Nevada	Oklahoma	Virginia
Alaska	Illinois	Michigan	New Mexico	Pennsylvania	West Virginia
Arkansas	Indiana	Mississippi	New York	Tennessee	Wyoming
California	Kansas	Montana	North Dakota	Texas	
Colorado	Kentucky	Nebraska	Ohio	Utah	

- 2) EPA compared the total well starts and feet drilled for the above states to the totals from the ENVERUS dataset. Where there was no comparison or significant differences (>30%) between the totals, EPA researched the states OGC websites to download the exploration data.

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- a. Four states (Arizona, Maryland, Oregon, and South Dakota) were not on the RIGDATA list and EPA researched confirmed via their OGC websites that no drilling occurred in 2020.
- b. RIGDATA identified one state, Nevada, as having drilling activity in 2020, but the data were not available in Enverus or on the Nevada OGC website.
- c. For ten states (Florida, Idaho, Illinois, Indiana, Kentucky, Mississippi, Missouri, New York, Tennessee, and Virginia), there were no drilling data in the Enverus dataset. EPA downloaded exploration data from their respective OGC websites.
- d. For eight states (Alabama, Colorado, Kansas, Michigan, Nebraska, New Mexico, Oklahoma, and Wyoming), the Enverus totals appeared low compared to RIGDATA. As such, EPA supplemented the Enverus data with additional exploration data from their respective OGC websites, with the exception of Michigan (no drilling data available on its OGC website).
- e. The Enverus totals for four states (California, Ohio, Pennsylvania, and West Virginia) were greater than the RIGDATA totals, and no additional research was conducted.
- f. Finally, the following seven states (Alaska, Arkansas, Louisiana, Montana, North Dakota, Texas, and Utah) Enverus and RIGDATA totals were within 30% and were not supplemented with additional data from their respective OGC websites.

### **2.1.2 State Oil and Gas Commission Websites**

As mentioned above, Enverus was the primary source for most oil, casinghead gas (associated gas), natural gas, and condensate activity data for 2020, with the exceptions of the following states:

- Idaho (liquids and gas)
- Indiana (liquids and gas)
- Mississippi (liquids and gas)
- Missouri (liquids and gas)
- Oregon (liquids and gas)
- Virginia (gas only)

For some states, the Enverus data was supplemented with state data or scaled to match published totals from the OGC website:

- Arkansas. Oil production from Enverus was low compared to the EIA state total. Thus, the Enverus oil well data were scaled up to align better with EIA.
- Nevada. Gas production from Enverus were low compared to the EIA state total. Additional production wells were supplemented with the Enverus data to better align with the EIA state total.
- New York. Oil and gas production from Enverus were low compared to the EIA state totals. Additional production wells were supplemented with the Enverus data to better align with the EIA state totals.

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For four states, 2020 production data were not available from the Enverus dataset or their OGC websites. (It's possible that the data may be available in the coming months.) As such, prior year data were carried-forward and scaled to match the EIA production for 2020.

- Illinois. County-level oil production for 2019 were obtained from its oil and gas association website and were scaled to 2020 production based on the ratio of total EIA production for years 2020 and 2019. County-level gas production from the 2017 Oil and Gas Tool were adjusted to 2020 production based on the ratio of total EIA production for years 2020 and 2017.
- Kentucky. County-level oil and gas production for 2019 were obtained from its OGC website and were scaled to 2020 production based on the ratio of total EIA production for years 2020 and 2019.
- Maryland. County-level gas production from the 2017 Oil and Gas Tool were adjusted to 2020 production based on the ratio of total EIA production for years 2020 and 2017.
- Tennessee. Well-level oil and gas production for 2016 were obtained from a prior Enverus data pull, and production were scaled to 2020 based on the ratio of total EIA production for years 2020 and 2016.

Produced water data were primarily available in Enverus for most of the states. When not reported in Enverus, information was obtained from the state's oil and gas commission website (e.g., Pennsylvania) or directly from the state (e.g., Kansas). If produced water data were not available in either Enverus or from the state, then activity estimates were generated for this source category based on statewide-developed production factors within a state (e.g., Texas) or from third-party analysis report (e.g., Oklahoma).<sup>8</sup>

Well completions were primarily available in Enverus for most of the states. When not reported in Enverus, information was obtained from the state's oil and gas commission website (e.g., Indiana). If well completions data were not available in either Enverus or the state's oil and gas commission websites, then no emission estimates were generated for this source category (e.g., Arizona).

As a result of this analysis, data from the following state oil and gas commission websites were used to compile the activity data in the tool:

- Alabama Oil and Gas Board: <https://www.ogb.state.al.us/ogb/wells>
- Arkansas Oil and Gas Conservation Commission: <http://aogc.state.ar.us/data/completion.aspx>
- Colorado: <https://cogcc.state.co.us/data2.html#/downloads>

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<sup>8</sup> Veil Environmental. U.S. Produced Water Volumes and Management Practices in 2017. February 2020. Internet address: [http://veilenvironmental.com/publications/pw/pw\\_report\\_2017\\_final.pdf](http://veilenvironmental.com/publications/pw/pw_report_2017_final.pdf)



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- Florida Department of Environmental Protection: <https://floridadep.gov/water/oil-gas/content/oil-and-gas-permit-database>
- Idaho Oil and Gas Conservation Commission: <https://ogcc.idaho.gov/monthly-and-annual-reports/> and <https://ogcc.idaho.gov/well-files/>
- Illinois State Geological Services: <https://clearinghouse.isgs.illinois.edu/data/geology/location-points-isgs-wells-and-borings-database> and [https://isgs-oas.isgs.illinois.edu/reports/rwservlet?oil\\_permit\\_activity](https://isgs-oas.isgs.illinois.edu/reports/rwservlet?oil_permit_activity)
- Indiana Department of Natural Resources: <https://www.in.gov/dnr/oil-and-gas/publications/monthly-reports/> and <https://www.in.gov/dnr/dnroil/5447.htm>
- Kansas Geological Services: [https://www.kgs.ku.edu/PRS/Ora\\_Archive/ks\\_wells.zip](https://www.kgs.ku.edu/PRS/Ora_Archive/ks_wells.zip)
- Kentucky Geological Services: <https://kgs.uky.edu/kygeode/services/oilgas/>
- Mississippi Oil and Gas Board: <https://www.ogb.state.ms.us/wellsearch.php> and <https://www.ogb.state.ms.us/proddata.php>
- Missouri Department of Natural Resources: <https://dnr.mo.gov/land-geology/businesses-landowners-permittees/permits/oil-gas>
- Nebraska Oil and Gas Conservation Commission: <http://www.nogcc.ne.gov/Publications/NebraskaWellData.zip>
- Nevada Division of Minerals: [https://data.nbmng.unr.edu/public/OilGas/Logs/oilgas\\_well\\_index\\_20200106.xlsx](https://data.nbmng.unr.edu/public/OilGas/Logs/oilgas_well_index_20200106.xlsx)
- New Mexico Oil Conservation Division: <https://wwwapps.emnrd.nm.gov/ocd/ocdpermitting/Data/Wells.aspx>
- New York Department of Conservation: <https://www.dec.ny.gov/fs/data/wellDOS.zip> and <https://www.dec.ny.gov/energy/36159.html>
- Oklahoma Corporation Commission: <https://www.dec.ny.gov/energy/36159.html>
- Oregon Department of Geology and Mineral Industries: [https://www.oregongeology.org/mlrr/mist/12-2020\\_MistGasField\\_Report.xlsx](https://www.oregongeology.org/mlrr/mist/12-2020_MistGasField_Report.xlsx)
- Pennsylvania Department of Environmental Protection: <https://www.depgreenport.state.pa.us/ReportExtracts/OG/OilGasWellWasteReport>
- Tennessee Department of Environment and Conservation: [https://dataviewers.tdec.tn.gov/pls/enf\\_reports/f?p=9034:34300:0::NO::](https://dataviewers.tdec.tn.gov/pls/enf_reports/f?p=9034:34300:0::NO::)
- Virginia Department of Environmental Quality: <https://energy.virginia.gov/dgo inquiry/frmMain.aspx?ctl=9>, <https://dmme.virginia.gov/dgo inquiry/frmMain.aspx?ctl=1>, and <https://energy.virginia.gov/dgo inquiry/frmMain.aspx?ctl=2>
- Wyoming Oil and Gas Conservation Commission: <http://pipeline.wyo.gov/SpudcompcompMenu.cfm?Skip=%27Y%27&oops=ID70897> and <http://pipeline.wyo.gov/SpudReportsMenu.cfm?Skip=%27Y%27&oops=ID20545>

### **2.1.3 National Production Summary**

A summary of the resulting oil and gas 2020 production statistics by state is presented in Table 2-4. This includes key activity indicators such as natural gas production (associated gas, gas well, and coalbed methane gas), crude oil production, and condensate production. States not listed in Table 2-4 (e.g. Connecticut and North Carolina) did not have any oil or gas production in 2020.

**Table 2-4. Oil and Gas Production by State**

State	Oil Wells	Gas Wells	CBM Wells	Oil (BBL)	Associated Gas (MMCF)	Gas Well Gas (MMCF)	Condensate (BBL)	CBM Gas (MMCF)	CBM Condensate (BBL)
Alabama	359	199	4,985	3,909,836	18,203	50,697	15,678	45,114	37,230
Alaska	1,632	225	0	159,536,232	2,854,007	594,034	4,315,721	0	0
Arizona	5	6	0	5,581	1	69	0	0	0
Arkansas	851	8,699	47	4,141,093	4,241	480,905	2,079	841	0
California	41,677	1,715	0	143,756,658	111,243	46,335	116,162	0	0
Colorado	12,275	18,258	4,877	166,381,709	1,093,765	618,610	1,265,105	279,087	90,950
Florida	51	0	0	1,366,217	13,777	0	0	0	0
Idaho	0	2	0	0	0	77	1,400	0	0
Illinois	21,962	652	60	7,166,000	0	1,578	0	265	0
Indiana	4,310	501	110	1,322,888	0	3,410	0	908	0
Kansas	30,253	13,408	3,646	28,227,649	16,400	131,865	23,810	15,953	6,591
Kentucky	10,162	18,664	0	2,281,543	51	93,708	0	0	0
Louisiana	15,213	15,108	4	35,602,684	135,964	3,012,830	632,801	53	4,166
Maryland	0	1	0	0	0	10	0	0	0
Michigan	2,875	7,120	0	4,009,961	5,997	58,088	4,115	0	0
Mississippi	1,378	1,165	0	14,117,103	10,602	17,526	46,844	0	0
Missouri	817	8	0	62,328	0	1	0	0	0
Montana	3,509	4,794	1	18,954,597	80,097	25,716	27,881	2	0
Nebraska	1,313	125	0	1,591,335	22	328	0	0	0
Nevada	46	0	0	207,989	8	0.00	0	0	0
New Mexico	20,759	18,022	5,253	369,715,649	1,388,698	425,349	697,888	201,108	8,656
New York	2,831	6,139	0	216,673	346	11,667	381	0	0
North Dakota	14,646	176	0	432,508,118	994,553	1,186	3,454	0	0
Ohio	15,937	19,423	0	23,204,371	310,989	2,038,650	429,217	0.0	0
Oklahoma	22,938	24,082	2,323	169,919,695	1,407,768	1,225,930	2,233,816	20,098	489,860
Oregon	0	10	0	0	0	320	0	0	0
Pennsylvania	17,415	56,545	300	4,013,618	140,965	7,020,239	1,624,029	4,402	1,534
South Dakota	135	45	0	1,045,161	4,394	338	1,499	0	0

**Table 2-4. Oil and Gas Production by State**

State	Oil Wells	Gas Wells	CBM Wells	Oil (BBL)	Associated Gas (MMCF)	Gas Well Gas (MMCF)	Condensate (BBL)	CBM Gas (MMCF)	CBM Condensate (BBL)
Tennessee	990	772	0	164,212	217	2,553	788	0	0
Texas	185,468	72,999	109	1,794,528,650	6,131,172	4,090,659	4,282,253	4,446	106,572
Utah	4,783	4,404	900	29,846,260	82,700	127,609	377,837	30,482	0
Virginia	12	1,893	6,040	4,736	235	16,139	0	86,409	0
West Virginia	2,885	40,946	432	15,448,617	478,616	2,082,182	4,040,975	5,776	0
Wyoming	10,603	10,868	4,399	84,922,888	437,785	950,818	3,882,676	83,468	6,047
<b>Total</b>	<b>448,090</b>	<b>346,974</b>	<b>33,486</b>	<b>3,518,180,050</b>	<b>15,722,817</b>	<b>23,129,426</b>	<b>24,026,408</b>	<b>778,413</b>	<b>751,606</b>

## **2.2 Process Characterization Data**

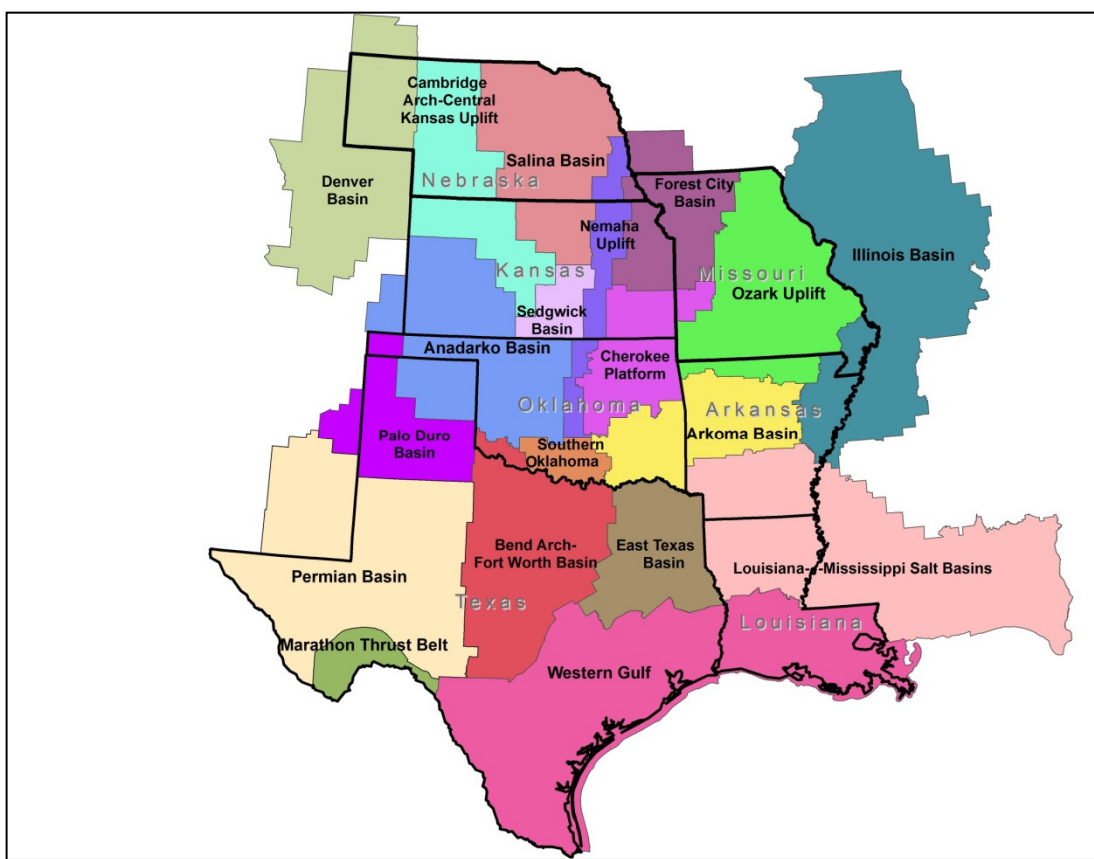
As described in the CenSARA<sup>9</sup> study, while activities can vary within a basin (e.g. both oil and gas operations), the geologically influenced characteristics of a specific basin (e.g. depth, pressure, presence of water, oil quality, gas composition) directly affect activity parameters that describe oil and gas operations within the basin boundaries, and in turn, influence emissions. A basin therefore represents a detailed but tractable geographic unit for development of emissions factors and other process characterization data for oil and gas nonpoint source emissions estimates.

In the CenSARA study, oil and gas nonpoint source emissions were estimated for each county within a discrete basin based on equipment characterization, activity data, and emission factors developed specifically for that basin. This equipment, activity, and emission factor data were obtained through industry surveys, a review of oil and gas datasets compiled by state and local agencies, and from existing studies.

Figure 2-1 below illustrates the 19 oil and gas basins included in the geographic scope of coverage of the CenSARA study.

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<sup>9</sup> ENVIRON International Company. Oil and Gas Emission Inventory Enhancement Project for CenSARA States. December 21, 2012. Internet address: [www.censara.org/filedepot/folder/10](http://www.censara.org/filedepot/folder/10)



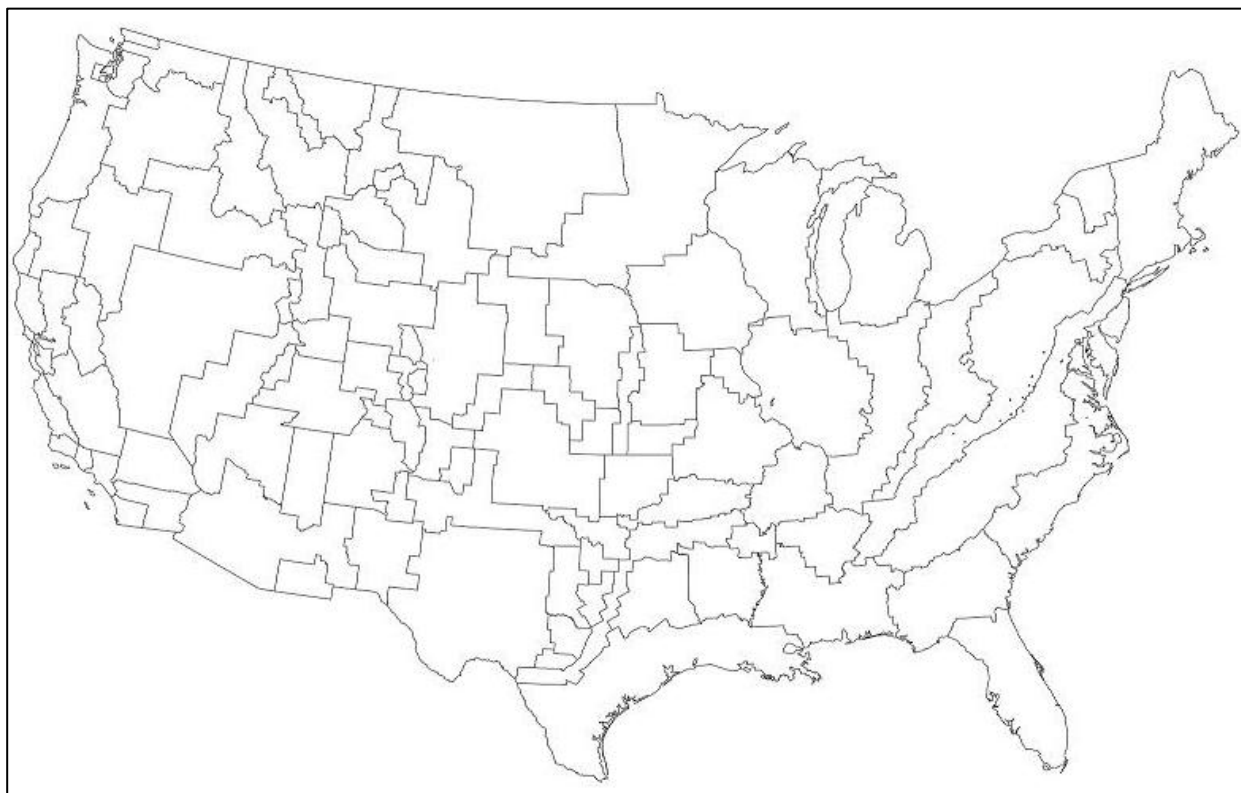
**Figure 2-1. Oil and Gas Basins Covered by the CenSARA Study**

Nationally, the remainder of the country was sub-divided into oil and gas basins (as defined by the geologic provinces published by the American Association of Petroleum Geologists (AAPG)) as used under Subpart W of the Greenhouse Gas Reporting Program (GHGRP).<sup>10</sup>

Using the AAPG definitions, the country is divided into 114 distinct oil and gas basins. Figure 2-2 below illustrates the geographic division of the country into oil and gas basins as defined by the geologic provinces published by the AAPG.

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<sup>10</sup> U.S. EPA, 2013. Subpart W Basin and County Combinations. Internet address: <http://www.cedsupport.com/confluence/display/help/Subpart+W+Basin+and+County+Combinations>



**Figure 2-2. Oil and Gas Basins as Defined by the Geologic Provinces Published by the AAPG**

The basic methodology employed in development of the CenSARA inventory was used to develop the national tool described in this report. However, during development and review of the tool by various stakeholders as part of the initial tool development for the 2011 NEI, it was determined that county-level resolution was needed to accommodate differing operational characteristics within a basin. Therefore, the tool currently resolves equipment characterization and activity data down to the county level.

For the CenSARA states, the input data from the CenSARA study have been used in the tool. For several oil and gas basins located in states adjacent to the CenSARA states, the AAPG basin definitions overlap into the CenSARA states. Therefore, CenSARA basin-specific data was used to initially populate the tool database for these basins. Table 2-5 identifies the basins adjacent to the CenSARA states where CenSARA basin-specific data was initially input into the tool.

**Table 2-5. Oil and Gas Basins Adjacent to CenSARA States**

<b>AAPG Basin</b>	<b>Affected States</b>	<b>CenSARA basin</b>
Anadarko Basin	CO	Anadarko Basin
Las Animas Arch	CO	Cambridge Arch-Central Kansas Uplift
Chadron Arch	SD	Cambridge Arch-Central Kansas Uplift

**Table 2-5. Oil and Gas Basins Adjacent to CenSARA States**

<b>AAPG Basin</b>	<b>Affected States</b>	<b>CenSARA basin</b>
Denver Basin	CO, WY	Denver Basin
Forest City Basin	IA	Forest City Basin
Upper Mississippi Embayment	KY, MS, TN	Illinois Basin
Desha Basin	MS	Louisiana-Mississippi Salt Basins
Illinois Basin	IL, IN, KY	Illinois Basin
Palo Duro Basin	NM	Palo Duro Basin
Permian Basin	NM	Permian Basin
Orogrande Basin	NM	Permian Basin
Mid-Gulf Coast Basin	AL, FL, MS	Western Gulf

Finally, for those basins falling entirely outside of the CenSARA states, national averages for equipment profiles and activity levels were developed based on the average of the surveyed basins within the CenSARA states. While this data were used to initially populate the input data for the tool database, many different state agencies, RPOs, and EPA supplied data that have been used in the current version of the tool.

For example, for certain source categories such as well completions and mud degassing, gas composition data developed by EPA for regulatory development purposes was used for the non-CenSARA basins.<sup>11</sup> Gas composition profiles developed under this effort were used as default profiles for:

- Associated Gas Venting (Oil Wells)
- Fugitives (Gas Wells)
- Gas-Actuated Pumps (Gas Wells)
- Liquids Unloading (Gas Wells)
- Mud Degassing (Oil and Gas Wells)
- Pneumatic Devices (Gas Wells)
- Well Completions (Oil and Gas Wells)

Appendix C contains a comprehensive list of each county in the United States and the associated AAPG oil and gas basin name, and under the CenSARA inventory (if applicable). Appendix C also identifies what data was initially used to populate the tool database for each county. This was either data from a specific CenSARA basin for the CenSARA states (CENSARA\_2012), data from a specific CenSARA basin for certain basins/counties adjacent to the CenSARA states as listed in Table 2-5 (CENSARA\_EXTENSION), or nationally-averaged data from all CenSARA basins (CENSARA\_AVG). While Appendix C identifies the initial reference for the data used to populate the tool database, numerous updates have been made to the tool since it was initially developed to incorporate EPA, state, and local data. The tool

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<sup>11</sup> U.S. EPA, 2011. "Composition of Natural Gas for use in the Oil and Natural Gas Sector Rulemaking", Memorandum from Heather P. Brown to Bruce Moore. July 28, 2011.



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database contains specific references at the county level for each data element used in the emission estimation algorithms.

Table 2-6 provides a broad overview of the types of data currently found in the tool. The table indicates “S” for state supplied data, “D” for default CenSARA data, “E” for EPA data, “B” for Bureau of Ocean Energy Management (BOEM) data, or “R” for RPO data (e.g. CenSARA or WRAP). In many instances, a mix of these data types are used to estimate emissions for a single source category. In these cases, each type of data found in the tool is identified.

**Table 2-6. Tool Data Sources by State and Source Type**

State	Artificial Lifts	Associated Gas	Condensate Tanks	Crude Oil Tanks	Dehydrators	Drilling Rigs	Fugitive Leaks	Gas-actuated Pumps	Heaters	Hydraulic Fracturing Pumps	Lateral/Gathering Compressor Engines	Liquids Unloading	Loading	Mud Degassing	Pneumatic Devices	Produced Water Tanks	Well Completions	Wellhead Compressor Engines
AL	D,S	D,E, R	D,E, R,S	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,S
AK	D	B,D, E	D,E, S	D,E, S	D,E, S	D	B,D, E	D,E	D	D	D,E	D,E	D,E	B,D, E	D	B,D, E	D,E	D
AZ	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D
AR	R	E,R	E,R	E,R	E,R	R	R	E,R	R	R	R	E,R	R	E,R	R	E,R	R	R
CA	D,S	D,E	D,E	D,E	D,S	D	D,E, S	D,S	D	D,S	D,E, S	D,E	D,E	D,E, S	D	D,E	D,E, S	D,S
CO	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R
FL	D,S	D,E, R	D,E, R,S	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,S
ID	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D
IL	D,R, S	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R,S	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R, S
IN	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R
KS	R	E,R	E,R	E,R	E,R	R	R,S	E,R	R	R	R,S	E,R	R	E,R, S	R	E,R, S	R	R
KY	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R
LA	R,S	E,R	E,R, S	E,R	E,R	R	R	E,R	R	R	R	E,R	R	E,R	R	E,R	R	R,S

**Table 2-6. Tool Data Sources by State and Source Type**

State	Artificial Lifts	Associated Gas	Condensate Tanks	Crude Oil Tanks	Dehydrators	Drilling Rigs	Fugitive Leaks	Gas-actuated Pumps	Heaters	Hydraulic Fracturing Pumps	Lateral/Gathering Compressor Engines	Liquids Unloading	Loading	Mud Degassing	Pneumatic Devices	Produced Water Tanks	Well Completions	Wellhead Compressor Engines
MD	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D
MI	D	D,E	D,E	D,E	D,E, S	D	D,E	D,E, S	D	D,S	D,E	D,E	D,E	D,E	D	D,E	D,E, S	D
MS	D,R, S	D,E, R	D,E, R,S	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R, S
MO	R	E,R	E,R	E,R	E,R	R	R	E,R	R	R	R	E,R	R	E,R	R	E,R	R	R
MT	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,E, R	D,E	D,E, R	D,R	D,E, R	D,E, R	D,E, R
NE	R	E,R	E,R	E,R	E,R	R	E,R	E,R	R	R	E,R	E,R	R	E,R	R	E,R	R	R
NV	D,S	D,E	D,E	D,E	D,E, S	D	D,E, S	D,E, S	D	D,S	D,E, S	D,E	D,E	D,E, S	D	D,E	D,E, S	D,S
NM	D,E, R,S	D,E, R,S	D,E, R,S	D,E, R,S	D,E, R,S	D,E, R,S	D,E, R,S	D,E, R	D,E, R,S	D,R	D,E, R,S	D,E, R	D,E, R,S	D,E, R,S	D,R	D,E, R,S	D,E, R,S	D,E, R,S
NY	D,S	D,E	D,E	D,E	D,E	D	D,E	D,E	D	D,S	D,E, S	D,E	D,E	D,E, S	D	D,E	D,E, S	D,S
ND	E,R	E,R	E,R	E,R	E,R	E,R	E,R	E,R	E,R	R	R	E,R	D,E	E,R	R	R	R	E,R
OH	D,S	D,E	D,E	D,E	D,E, S	D	D,E, S	D,E	D	D,S	D,E, S	D,E	D,E	D,E, S	D	D,E	D,E, S	D,S
OK	R,S	E,R	E,R, S	E,R	E,R	R	R	E,R	R	R	R	E,R	R	E,R	R	E,R	R	R,S
OR	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D
PA	D	D,E	D,E	D,E	D,E	D	D,E, S	D,E	D	D	D,E	D,E	D,E	D,E, S	D	D,E	D,E	D

**Table 2-6. Tool Data Sources by State and Source Type**

State	Artificial Lifts	Associated Gas	Condensate Tanks	Crude Oil Tanks	Dehydrators	Drilling Rigs	Fugitive Leaks	Gas-actuated Pumps	Heaters	Hydraulic Fracturing Pumps	Lateral/Gathering Compressor Engines	Liquids Unloading	Loading	Mud Degassing	Pneumatic Devices	Produced Water Tanks	Well Completions	Wellhead Compressor Engines
SD	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,E, R
TN	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R
TX	S	E,R	E,R, S	E,R	E,R, S	R	E,R	E,R	R,S	R,S	E,R	E,R	R,S	E,R, S	R	E,R, S	R,S	S
UT	D,R	D,E	D,E, R	D,E, R,S	D,E, R,S	D,R, S	D,E, R,S	D,E, R	D	D,R	D,E, R,S	D,E, R	D,E	D,E, R	D	D,E, R,S	D,E, R,S	D,R
VA	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D	D	D,E	D,E	D,E	D,E	D	D,E	D,E	D
WV	D	D,E, S	D,E	D,E	D,E	D	D,E, S	D,E	D	D	D,E, S	D,E, S	D,E	D,E	D,E	D,E, S	D,E	D
WY	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R	D,E, R	D,R	D,R	D,E, R	D,E, R	D,E, R	D,E, R	D,R	D,E, R,S	D,E, R	D,R

<sup>a</sup> D = Default data from CenSARA Study, E = EPA, R = RPO (CenSARA or WRAP), S = state, B = BOEM

### **2.3 Updates Since 2017**

The final version of the 2017 Nonpoint Oil and Gas Emission Estimation Tool was completed in October of 2019. The primary updates made since finalization of the 2017 version of the tool include:

- **Updated Activity Data.** Oil and gas exploration and production activity data was updated to reflect 2020 as described in Section 2.1 using data from the Enverus database, RIGDATA, and various state oil and gas commission websites.
- **Basin Factor Updates.** Basin factors were update using several data sources:
  - GHGRP data was analyzed to develop updated basin factors for several source categories including storage tanks, dehydrators, fugitive equipment leaks, heaters, pneumatic devices, and wellhead compressor engines.
  - Western Regional Air Partnership (WRAP) data was used to develop updated basin factors for several source categories for Montana, New Mexico, North Dakota, and South Dakota.
  - Data provided by the California Air Resources Board (CARB) was used to develop updated basin factors for several source categories.
- **Emission Factor Updates.** Drilling and hydraulic fracturing engine emission factors were updated using the MOVES model for 2020.
- **Temperature Updates.** Updated annual average temperature data by county using EPA's 2020 Weather Research Factorization (WRF) model data.

**3.0 SOURCE CATEGORY EMISSION ESTIMATION METHODOLOGIES**

Emissions for individual oil and gas nonpoint source categories were developed using a bottom-up approach that begins with developing mass emission rates for each pollutant based on an activity surrogate (e.g. tons per well, tons per barrel of oil, tons per feet drilled). These by-surrogate emission rates were then scaled to county-level emissions by multiplying the emission rates by the scaling surrogate or activity from a particular county (e.g. gas well counts, horizontal feet drilled, crude oil production, etc.).

Emissions calculations are performed within the Microsoft Access database. Data field names and definitions for calculation inputs are shown in Appendix D (Data Element Dictionary) in the same format and nomenclature as they appear in the database tool. Appendix D also provides the national “default” value for each variable (and reference) used in the calculations when state-supplied data is unavailable. Refer to the instructions included in Appendices A and B for details on how the database is organized.

The following sections describe emissions calculations for each source category; it is noted that some of these methodologies may apply to multiple SCCs and thus, are calculated separately in the tool. Example calculations are provided for each source category. The examples are provided for illustrative purposes only and may not match the totals calculated by the tool due to rounding or updates to any of the activity or emission factor inputs.

Table 3.1 below identifies the source categories associated with each type of well (oil or gas), and the primary activity parameter used as the basis to scale emissions up to the county level.

**Table 3-1. Emission Sources by Well Type**

<b>Category</b>	<b>Activity Basis</b>	<b>Oil</b>	<b>CBM</b>	<b>Gas</b>
Artificial Lifts	Oil Well Count	Yes	No	No
Associated Gas	Oil Production	Yes	No	No
Coalbed Methane Dewatering Pump Engines	CBM Well Counts	No	Yes	No
Condensate Tanks	Condensate Production	No	Yes	Yes
Crude Oil Tanks	Oil Production	Yes	No	No
Dehydrators	Gas, Associated Gas, and CBM Production; Gas and CBM Well Counts	No	Yes	Yes
Drill Rigs	Estimated Feet Drilled	Yes	Yes	Yes
Fugitive Leaks	Oil, Gas, and CBM Well Count	Yes	Yes	Yes
Gas-Actuated Pumps	Oil, Gas, and CBM Well Count	Yes	Yes	Yes
Heaters	Oil, Gas, and CBM Well Count	Yes	Yes	Yes
Hydraulic Fracturing Pumps	Horizontal Spud Count	Yes	Yes	Yes
Lateral/Gathering Compressor Engines	Gas and CBM Well Count	No	Yes	Yes
Liquids Unloading	Gas and CBM Well Count	No	Yes	Yes
Loading	Oil and Condensate Production	Yes	Yes	Yes

**Table 3-1. Emission Sources by Well Type**

Category	Activity Basis	Oil	CBM	Gas
Mud Degassing	Spud Counts	Yes	Yes	Yes
Pneumatic Devices	Oil, Gas, and CBM Well Count	Yes	Yes	Yes
Produced Water Tanks	Produced Water Production	Yes	Yes	Yes
Well Completions	Completion Count	Yes	Yes	Yes
Wellhead Compressors	Gas and CBM Well Count	No	Yes	Yes

### **3.1 Artificial Lifts**

Artificial lifts refer specifically to engines located at oil wells that provide lift to the liquids in a well up to the wellhead. Generally, artificial lift engines are small natural gas-fired engines. In the past decade, there has been an increased use of electrified artificial lift engines powered by the grid; for this kind, emissions are assumed to be zero. Figure 3-1 shows a pump jack with an artificial lift engine (inset).<sup>1</sup>



**Figure 3-1. Artificial Lift Engine**

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<sup>1</sup> Personal Communication between Ms. Julie McDill, MARAMA, Ms. Megan Murphy, WVDEP, and Mr. Mike Pring, Eastern Research Group, Inc. January 24, 2014.

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The basic methodology for estimating emissions from a single non-electrified artificial lift engine is shown below:

$$\text{Equation 1)} \quad E_{engine} = \frac{EF_i \times HP \times LF \times t_{annual}}{907,185}$$

where:

$E_{engine}$  are emissions from an artificial lift engine [ton/year/engine]

$EF_i$  is the emissions factor of pollutant  $i$  [g/hp-hr]

$HP$  is the horsepower of the engine [hp]

$LF$  is the load factor of the engine

$t_{annual}$  is the annual number of hours the engine is used [hr/yr]

907,185 is the unit conversion factor g/ton

### Extrapolation to county-level emissions

Artificial lift engine emissions have been scaled up to the county level on the basis of oil well counts. The methodology for scaling up artificial lift engine emissions is shown below:

$$\text{Equation 2)} \quad E_{engine,TOTAL} = n \times E_{engine} \times f_{pumpjack} \times (1 - FE) \times W_{OIL,TOTAL}$$

where:

$E_{engine,TOTAL}$  is the total emissions from artificial lift engines in a county [ton/yr]

$n$  is the total number of artificial lift engines per well [engine/well]

$E_{engine}$  is the total emissions from an artificial lift engine (as shown in Equation 1) [ton/yr/engine]

$f_{pumpjack}$  is the fraction of oil wells with artificial lift engines

$FE$  is the fraction of artificial lift engines that are electric

$W_{OIL,TOTAL}$  is the total number of **oil** wells in a county [wells]

### Example Calculation for Artificial Lift:

Using the equations provided above, NO<sub>x</sub> emissions from artificial lift engines in Calhoun County, Arkansas were calculated as follows:

$$E_{engine} = \frac{EF \times HP \times LF \times t_{annual}}{907,185}$$

where:

$E_{engine}$  = emissions from an artificial lift engine [ton/yr/engine]

$EF = 8.24$  [g/hp-hr]

$HP = 77.5$  [hp]

$LF = 0.85$  (load factor for the engine)

$t_{annual} = 8,000$  [hr/yr]

907,185 [g/ton]



Therefore:

$$E_{engine} = \frac{8.24 \times 77.5 \times 0.85 \times 8,000}{907,185}$$

$$E_{engine} = 4.79 \text{ [ton/yr/engine]}$$

Total NO<sub>x</sub> emissions from all artificial lift engines in Calhoun County can be evaluated as follows:

$$E_{engine,TOTAL} = n \times E_{engine} \times f_{pumpjack} \times (1 - FE) \times W_{OIL,TOTAL}$$

where:

$E_{engine,TOTAL}$  is the total emissions from artificial lift engines in a county [ton/yr]

$n = 1$  [engine/well]

$E_{engine} = 4.79$  [ton/yr/engine]

$f_{pumpjack} = 0.95$  (fraction of oil wells with artificial lift engines)

$FE = 0.965$  (fraction of artificial lift engines that are electrified)

$W_{OIL,TOTAL} = 18$  [wells]

Therefore:

$$E_{engine,TOTAL} = 1 \times 4.79 \times 0.95 \times (1 - 0.965) \times 18$$

$$E_{engine, TOTAL} = 2.86 \text{ [ton/yr]}$$

### 3.2 Associated Gas Venting and Flaring

This section refers to the practice of venting associated gas from oil wells which sometimes takes place when the well is not connected to a gas sales pipeline or when the amount of gas produced by the well is so limited that is not profitable for capture. In some areas of the country, this gas may be flared.

The calculation methodology for estimating county-wide emissions from associated gas venting is shown below in Equation 3:

$$\text{Equation 3) } E_{assoc, gas, i} = \left( \frac{P \times (Q_{assoc, gas, i}) \times P_{oil}}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{f_i}{907,185} \times (1 - F_{flare} \times C_{captured} \times C_{efficiency})$$

where:

$E_{assoc, gas, i}$  is the county-wide emissions of pollutant  $i$  from associated gas venting [ton/yr]

$P$  is atmospheric pressure [1 atm]

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$Q_{assoc,gas,i}$  is the venting rate of associated gas per unit of oil production [MCF/bbl]

$P_{oil}$  is the annual county-wide oil production [bbl/yr]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of the gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$f_i$  is the mass fraction of pollutant  $i$  in the associated gas

$F_{flare}$  is the fraction of associated gas controlled with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

#### **Flaring emissions from associated gas controls**

Emissions from flaring controls applied to associated gas are included in this source category. The methodology for estimating emissions from flaring of associated gas is described below:

$$\text{Equation 4)} \quad E_{flare,assoc,gas} = \left( \frac{EF_i \times Q_{assoc,gas} \times F \times (C_{captured}) \times (C_{efficiency}) \times HV}{1,000} \times P_{oil} \right) / 2,000$$

where:

$E_{flare,assoc,gas}$  is the county-wide flaring emissions of pollutant  $i$  from vented associated gas [ton/yr]

$EF_i$  is the flaring emissions factor for pollutant  $i$  [lb/MMBtu]

$Q_{assoc,gas}$  is the volume of associated gas vented per barrel of oil produced [MCF/bbl]

$F$  is the fraction of associated gas vent controlled with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

$HV$  is the local heating value of the gas [BTU/SCF]

$P_{oil}$  is the annual county-wide oil production [bbl/yr]

2,000 is the unit conversion factor lbs/ton

The methodology for estimating SO<sub>2</sub> emissions from flaring of associated head gas is shown below:

Equation 5)

$$E_{assocgas,flare,SO_2} = \left( \frac{P \times (Q_{assoc,gas}) \times P_{oil}}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times 2 \times \frac{f_{H2S}}{907,185} \times F_{flare} \times (C_{captured}) \times (C_{efficiency})$$

where:

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$E_{assoc,gas,flare,SO_2}$  is the county-wide  $SO_2$  emissions from flaring of associated gas [ton/yr]

$P$  is atmospheric pressure [1 atm]

$Q_{assoc,gas}$  is vented volume of associated gas per barrel of oil [MCF/bbl]

$P_{oil}$  is the annual county-wide oil production [bbl/yr]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of the associated gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$f_{H_2S}$  is the mass fraction of  $H_2S$  in the associated gas

$F_{flare}$  is the fraction of associated gas vents controlled by flare

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

### Extrapolation to county-level emissions

County-wide emissions from associated gas venting and associated gas flaring are estimated directly from Equations 3-5. The sum of venting and flaring emissions by pollutant yield the total county-wide emissions from associated head gas that is not captured for sale.

### Example Calculation for Associated Gas Venting:

Using the equations provided above, VOC emissions for associated gas venting in Columbia County, Arkansas were calculated as follows:

$$E_{assoc,gas} = \left( \frac{P \times (Q_{assoc,gas}) \times P_{oil}}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{f}{907,185} \times (1 - F_{flare} \times C_{captured} \times C_{efficiency})$$

where:

$E_{assoc,gas}$  is the county-wide emissions of VOC from associated gas venting [ton/bbl]

$P = 1$  [atm]

$Q_{assoc,gas} = 0.00365$  [MCF/bbl]

$P_{oil} = 1,231,945$  [bbl/yr]

$R = 0.082$  [L-atm/mol-K]

$MW_{gas} = 24.25$  [g/mol]

$T = 298$  [K]

$f = 0.262$  (the mass fraction of VOC in the associated gas)

$F_{flare} = 0$  (the fraction of associated gas vent controlled with flares)

$C_{captured} = 1.0$  (capture efficiency expressed as fraction)

$C_{efficiency} = 0.98$  (control efficiency expressed as fraction)

$3.5 \times 10^{-5}$  [MCF/L]

907,185 [g/ton]

Therefore:

$$E_{assoc, gas} = \left( \frac{P \times (0.00365) \times 1,231,945}{\left( \frac{0.082}{24.25} \right) \times 298 \times 3.5 \times 10^{-5}} \right) \times \frac{0.262}{907,185} \times (1 - 0 \times 1.0 \times 0.98)$$

$$E_{assoc, gas} = 36.82 \text{ [ton/yr]}$$

Flaring emissions would be calculated similarly to the example given above for condensate tanks. In this case, since it is assumed that the fraction of associated gas controlled by flares is zero, there are no flare emissions.

### **3.3 Coalbed Methane Dewatering Pump Engines**

Coalbed methane (CBM) dewatering pump engines refer specifically to engines located at CBM wells that provide lift to bring the water in the well up to the wellhead. Removing water from CBM wells allows the methane to flow freely through the fissures in the coal seam to the well. Generally, CBM dewatering pump engines are small natural gas or diesel-fired engines. Where electricity is available, CBM dewatering pump engines may be powered by electric motors or electric-powered submersible pumps may be used for removing water. For CBM dewatering pumps powered by electricity, emissions are assumed to be zero.

Figure 3-2 shows a CBM dewatering pump.



**Figure 3-2. Coalbed Methane Dewatering Pump**

The basic methodology for estimating emissions from a single non-electrified CBM dewatering pump engine is shown below:

Equation 1) 
$$E_{engine} = \frac{EF_i \times HP \times LF \times t_{annual}}{907,185}$$

where:

$E_{engine}$  are emissions from a CBM dewatering pump engine [ton/year/engine]

$EF_i$  is the emissions factor of pollutant  $i$  [g/hp-hr]

$HP$  is the horsepower of the engine [hp]

$LF$  is the load factor of the engine

$t_{annual}$  is the annual number of hours the engine is used [hr/yr]

907,185 is the unit conversion factor g/ton

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### **Extrapolation to county-level emissions**

CBM dewatering pump engine emissions have been scaled up to the county level on the basis of CBM well counts. The methodology for scaling up CBM dewatering pump engine emissions is shown below:

$$\text{Equation 2)} \quad E_{engine, TOTAL} = n \times E_{engine} \times f_{pump} \times (1 - FE) \times W_{CBM, TOTAL}$$

where:

$E_{engine, TOTAL}$  is the total emissions from CBM dewatering pump engines in a county [ton/yr]  
 $n$  is the total number of CBM dewatering pump engines per well, generally equal to 1 ( $n=1$ ) [engine/well]  
 $E_{engine}$  is the total emissions from a CBM dewatering pump engine (as shown in Equation 1) [ton/yr/engine]  
 $f_{pump}$  is the fraction of CBM wells with dewatering pump engines  
 $FE$  is the fraction of CBM dewatering pump engines that are electric  
 $W_{CBM, TOTAL}$  is the total number of CBM wells in a county [wells]

### **Example Calculation for CBM dewatering pump engines:**

Using the equations provided above, NO<sub>x</sub> emissions from CBM dewatering pump engines in Calhoun County, Arkansas may be calculated as follows:

$$E_{engine} = \frac{EF \times HP \times LF \times t_{annual}}{907,185}$$

where:

$E_{engine}$  = emissions from a CBM dewatering pump engine [ton/yr/engine]  
 $EF = 8.24$  [g/hp-hr]  
 $HP = 77.5$  [hp]  
 $LF = 0.85$  (load factor for the engine)  
 $t_{annual} = 8,000$  [hr/yr]  
 $907,185$  [g/ton]

Therefore:

$$E_{engine} = \frac{8.24 \times 77.5 \times 0.85 \times 8,000}{907,185}$$

$$E_{engine} = 4.79 \text{ [ton/yr/engine]}$$

Total NO<sub>x</sub> emissions from all CBM dewatering pump engines in Calhoun County can be evaluated as follows:

$$E_{engine, TOTAL} = n \times E_{engine} \times f_{pump} \times (1 - FE) \times W_{CBM, TOTAL}$$

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where:

$E_{engine,TOTAL}$  is the total emissions from CBM dewatering pump engines in a county [ton/yr]

$n = 1$  [engine/well]

$E_{engine} = 4.79$  [ton/yr/engine]

$f_{pump} = 0.95$  (fraction of CBM wells with CBM dewatering pump engines)

$FE = 0.965$  (fraction of CBM dewatering pump engines that are electrified)

$W_{CBM,TOTAL} = 18$  [wells]

Therefore:

$$E_{engine,TOTAL} = 1 \times 4.79 \times 0.95 \times (1 - 0.965) \times 18$$

$$E_{engine,TOTAL} = 2.86 \text{ [ton/yr]}$$

[Note – the example above is for illustrative purposes only, there are currently no default factors available to estimate emissions from CBM dewatering pump engines.]

### **3.4 Condensate Tanks**

Condensate storage tanks are considered a significant source of VOC emissions. Liquid storage tank losses are generated by flashing and by working and breathing processes, although generally the emissions are dominated by flashing losses. This analysis uses a combined-losses emissions factor and assumes that the gas compositions from both processes are identical. Figure 3-3 shows liquid storage tanks in the Barnett Shale.



**Figure 3-3. Liquid Storage Tanks**

The methodology for estimating condensate tank combined losses is shown below:

Equation 6)

$$E_{condensate,tanks,VOC} = \frac{EF_{condensate,tanks,VOC}}{2,000} \times [1 - F_{VRU} - F_{flare} \times C_{captured} \times C_{efficiency}]$$

### Nonpoint Oil and Gas Emissions Estimation Tool

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where:

$E_{condensate,tanks,VOC}$  is the VOC emissions per liquid unit throughput from condensate tanks [tons/bbl]

$EF_{condensate,tanks,VOC}$  is the VOC emissions factor for combined losses from condensate tanks [lb-VOC/bbl]

$F_{VRU}$  is the fraction of condensate tanks controlled by vapor recovery units

$F_{flare}$  is the fraction of condensate tanks with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

2,000 is the unit conversion factor lb/ton

The methodology for estimating condensate tank combined losses from other pollutants i in the gas is shown below:

Equation 7) 
$$E_{condensate,tanks,i} = E_{condensate,tanks,VOC} \times \frac{weight\ fraction_i}{weight\ fraction_{VOC}}$$

where:

$E_{condensate,tanks,i}$  is the emissions of pollutant i per liquid unit throughput from condensate tanks [tons/bbl]

$E_{condensate,tanks,VOC}$  is the VOC emissions per liquid unit throughput from condensate tanks [tons-VOC/bbl]

$(weight\ fraction_i/weight\ fraction_{VOC})$  is the mass-based weight fraction of pollutant i divided by the weight fraction of VOC in the gas

### Flaring emissions from condensate tank controls

This source category includes any flaring emissions associated with controls applied to condensate tanks. The methodology for estimating emissions from flaring of condensate tank flash gas is described below:

Equation 8)

$$E_{flare,tank,i} = P_{condensate} \times \left( Q_{condensate,tanks} \times F_{flare} \times (C_{captured}) \times (C_{efficiency}) \times \frac{EF_i \times HV}{1,000} \right) / 2,000$$

where:

$E_{flare,tank,i}$  is the county-wide flaring emissions of pollutant i from condensate tank controls [ton/yr]

$P_{condensate}$  is the annual county-wide condensate production [bbl/yr]

$Q_{condensate,tank}$  is the uncontrolled volume of tank losses vented per unit of condensate throughput [MCF/bbl]

$F_{flare}$  is the fraction of condensate tanks with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare



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$EF_i$  is the flaring emissions factor for pollutant  $i$  [lb/MMBtu]

$HV$  is the local heating value of the gas [BTU/SCF]

2,000 is the unit conversion factor lb/ton

1,000 is the unit conversion factor MCF/MMCF

The methodology for estimating SO<sub>2</sub> emissions from flaring of oil and condensate flash gas is shown below:

Equation 9)

$$E_{flare,tank,SO_2} = \left( \frac{P \times (Q_{condensate,tank} \times F_{flare} \times (C_{captured}) \times (C_{efficiency}) \times P_{condensate})}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times f_{H_2S} \times \frac{2}{907,185}$$

where:

$E_{flare,tank,SO_2}$  is the county-wide SO<sub>2</sub> flaring emissions from condensate tanks controls [ton/yr]

$P$  is atmospheric pressure [1 atm]

$Q_{condensate,tank}$  is the uncontrolled volume of tank losses vented per unit of condensate throughput [MCF/bbl]

$F_{flare}$  is the fraction of condensate tanks with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

$P_{condensate}$  is the annual county-wide condensate production [bbl/yr]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of the flash gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$f_{H_2S}$  is the mass fraction of H<sub>2</sub>S in the flash gas

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

### Extrapolation to county-level emissions

To estimate county-wide total controlled and uncontrolled condensate tank emissions, which includes venting and flaring, for each pollutant  $i$ , Equation 10 below is used:

Equation 10) 
$$E_{condensate,tanks,TOTAL,i} = E_{condensate,tanks,i} \times P_{condensate} \times F_{tank} + E_{flare,tanks,i}$$

where:

$E_{condensate,tanks,TOTAL,i}$  is the county-wide total emissions for pollutant  $i$  from condensate tanks [tons/yr]

$E_{condensate,tanks,i}$  is the combined losses of pollutant  $i$  per liquid unit throughput from condensate tanks [tons/bbl]

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$P_{condensate}$  is the annual county-wide condensate production [bbl/yr]

$F_{tank}$  is the fraction of condensate directed to tanks [%]

$E_{flare,tanks,i}$  is the county-wide flaring emissions of pollutant i from condensate tank controls [ton/yr]

#### **Example Calculation for Condensate Tanks:**

Using the equations provided above, VOC and SO<sub>2</sub> emissions from condensate tank venting and flaring in Columbia County, Arkansas were calculated as follows:

Venting Emissions:

$$E_{condensate,tanks,VOC} = \frac{EF_{condensate,tanks,VOC}}{2,000} \times [1 - F_{VRU} - F_{flare} \times C_{captured} \times C_{efficiency}]$$

where:

$E_{condensate,tanks,VOC}$  is the VOC emissions per liquid unit throughput from condensate tanks [tons/bbl]

$EF_{condensate,tanks,VOC} = 3.60$  [lb-VOC/bbl]

$F_{VRU} = 0$  (fraction of condensate tanks controlled by a VRU)

$F_{flare} = 0.315$  (fraction of condensate tanks with flares)

$C_{captured} = 1.0$  (capture efficiency expressed as fraction)

$C_{efficiency} = 0.98$  (control efficiency expressed as fraction)

2,000 is the unit conversion factor lb/ton

Therefore:

$$E_{condensate,tanks,VOC} = \frac{3.60}{2,000} \times [1 - 0 - 0.315 \times 1 \times 0.98]$$

$$E_{condensate,tanks,VOC} = 0.001244 \text{ [tons/bbl]}$$

Flaring Emissions:

VOC emissions from flaring of condensate tank vapors may then be calculated as follows:

$$E_{flare,tank} = P_{condensate} \times \left( Q_{condensate,tanks} \times F_{flare} \times (C_{captured}) \times (C_{efficiency}) \times \frac{EF \times HV}{1,000} \right) / 2,000$$

where:

$E_{flare,tank}$  is the county-wide flaring emissions of VOC from condensate tank controls [ton/yr]

$P_{condensate} = 275,892$  [bbl/yr]

$Q_{condensate,tank} = 0.037$  [MCF/bbl]

$F_{flare} = 0.315$  (fraction of condensate tanks with flares)

$C_{captured} = 1.0$  (capture efficiency expressed as fraction)

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$C_{efficiency} = 0.98$  (control efficiency expressed as fraction)

$EF = 0.66$  [lb/MMBtu]

$HV = 2,597$  [BTU/SCF]

2,000 [lb/ton]

1,000 (conversion factor)

Therefore:

$$E_{flare,tank} = 275,892 \times \left( 0.037 \times 0.315 \times (1.0) \times (0.98) \times \frac{0.66 \times 2,597}{1,000} \right) / 2,000$$

$$E_{flare,tank} = 2.71 \text{ [ton/yr]}$$

Total VOC emissions from all condensate tanks in Columbia County can be evaluated as follows:

$$E_{condensate,tanks,TOTAL} = E_{condensate,tanks,VOC} \times P_{condensate} \times F_{tank} + E_{flare,tanks}$$

where:

$E_{condensate,tanks,TOTAL}$  is the county-wide total emissions of VOC from condensate tanks [ton/yr]

$E_{condensate,tanks,VOC} = 0.0012$  [tons/bbl]

$P_{condensate} = 275,892$  [bbl/yr]

$F_{tank} = 1$  (fraction directed to tanks)

$E_{flare,tanks} = 2.71$  [ton/yr]

Therefore:

$$E_{condensate,tanks,TOTAL} = 0.001244 \times 275,892 \times 1 + 2.71$$

$$E_{condensate,tanks,TOTAL} = 345.9 \text{ [ton/yr]}$$

### **3.5 Crude Oil Tanks**

Crude oil tanks are used to store liquid product at a well pad or central tank battery prior to transfer downstream to a refinery. Figure 3-4 shows a central tank battery (circled) in the Permian Basin adjacent to numerous well pads with pump jacks.<sup>2</sup>

Crude oil tank emissions are generated by working and breathing processes. The methodology for estimating oil tank venting emissions is shown in Equations 11-12. This methodology is based on a combined working and breathing losses VOC emissions factor on a per unit throughput basis (mass emissions per barrel of oil).

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<sup>2</sup> Google Earth, 2014. "Permian Basin Tank Battery." 32°28'16.26" N and 102°49'26.40" W. November 14, 2011. March 25, 2014.



**Figure 3-4. Permian Basin Tank Battery**

Equation 11)

$$E_{oil,tanks,VOC} = P_{oil} \times \frac{EF_{oil,tanks,VOC}}{2,000} \times F_{tank} \times [1 - F_{VRU} - F_{flare} \times C_{captured} \times C_{efficiency}]$$

where:

$E_{oil,tanks,VOC}$  is the county-wide annual VOC venting losses from oil tanks [tons-VOC/yr]

$P_{oil}$  is the annual county-wide oil production [bbl/yr]

$EF_{oil,tanks,VOC}$  is the VOC emissions factor for total losses from oil tanks [lb-VOC/bbl]

$F_{tank}$  is the fraction of oil directed to tanks [%]

$F_{VRU}$  is the fraction of oil tanks controlled by vapor recovery units

$F_{flare}$  is the fraction of oil tanks with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

2,000 is the unit conversion factor lb/ton

The methodology for estimating crude oil tank losses from other pollutants  $i$  in the emissions is shown below:

Equation 12)

$$E_{oil,tanks,i} = E_{oil,tanks,VOC} \times \frac{weight\ fraction_i}{weight\ fraction_{VOC}}$$

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where:

$E_{oil,tanks,i}$  is the county-wide annual losses of pollutant  $i$  from oil tanks [tons/yr]  
 $E_{oil,tanks,VOC}$  is the county-wide annual VOC venting losses from oil tanks [tons-VOC/yr]  
( $weight\ fraction_i / weight\ fraction_{VOC}$ ) is the mass-based weight fraction of pollutant  $i$  divided by the weight fraction of VOC in the gas

### **Flaring emissions from oil tank controls**

This source category includes any flaring emissions associated with controls applied to crude oil tanks. The methodology for estimating emissions from flaring of oil tank gas losses is described below:

$$\text{Equation 13) } E_{flare,tank,i} = P_{oil} \times \left( Q_{oil,tanks,flash} \times F_{flare} \times (C_{captured}) \times (C_{efficiency}) \times \frac{EF_i \times HV}{1,000} \right) / 2,000$$

where:

$E_{flare,tank,i}$  is the county-wide emissions from crude oil tank flaring [ton/yr]  
 $P_{oil}$  is the annual county-wide oil production [bbl/yr]  
 $Q_{oil,tanks,flash}$  is the volume of gas flared per unit of oil throughput [MCF/bbl]  
 $F_{flare}$  is the fraction of oil tanks with flares  
 $C_{captured}$  is the capture efficiency of the flare  
 $C_{efficiency}$  is the control efficiency of the flare  
 $EF_i$  is the flaring emissions factor for pollutant  $i$  [lb/MMBtu]  
 $HV$  is the local heating value of the gas [BTU/SCF]  
1,000 is the unit conversion factor MCF/MMCF  
2,000 is the unit conversion factor lb/ton

The methodology for estimating SO<sub>2</sub> emissions from flaring of oil tank losses is shown below:

Equation 14)

$$E_{flare,tank,SO_2} = \left( \frac{P \times (Q_{oil,tanks,flash} \times F_{flare} \times (C_{captured}) \times (C_{efficiency}) \times P_{oil})}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times f_{H_2S} \times \frac{2}{907,185}$$

where:

$E_{flare,tank,SO_2}$  is the county-wide SO<sub>2</sub> emissions from flaring controls in oil tanks [ton/yr]  
 $P$  is atmospheric pressure [1 atm]  
 $Q_{oil,tank,flash}$  is the volume of gas vented per unit of oil throughput [MCF/bbl]  
 $F_{flare}$  is the fraction of crude oil tanks with flares  
 $C_{captured}$  is the capture efficiency of the flare

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$C_{efficiency}$  is the control efficiency of the flare  
 $P_{oil}$  is the annual county-wide oil production [bbl/yr]  
 $R$  is the universal gas constant [0.082 L-atm/mol-K]  
 $MW_{gas}$  is the molecular weight of the gas [g/mol]  
 $T$  is the atmospheric temperature [298 K]  
 $f_{H_2S}$  is the mass fraction of H<sub>2</sub>S in the gas  
 $3.5 \times 10^{-5}$  is the unit conversion factor MCF/L  
907,185 is the unit conversion factor g/ton

#### Extrapolation to county-level emissions

Equations 11-14 provide county-wide estimates directly using by-county oil production as a surrogate. The total county-wide emissions from crude oil tanks are the sum of flaring and crude tank working and breathing emissions (by-pollutant).

#### Example Calculation for Crude Oil Tanks:

Using the equations provided above, VOC emissions for crude oil tanks in Columbia County, Arkansas were calculated as follows:

$$E_{oil,tanks,VOC} = P_{oil} \times \frac{EF_{oil,tanks,VOC}}{2,000} \times F_{tank} \times [1 - F_{VRU} - F_{flare} \times C_{captured} \times C_{efficiency}]$$

where:

$E_{oil,tanks,VOC}$  is the county-wide annual VOC venting losses from oil tanks [tons-VOC/yr]  
 $P_{oil} = 1,231,945$  [bbl/yr]  
 $EF_{oil,tanks,VOC} = 0.287$  [lb-VOC/bbl]  
 $F_{tank} = 1$  (fraction directed to tanks)  
 $F_{VRU} = 0$  (fraction controlled by VRU)  
 $F_{flare} = 0$  (fraction flared)  
 $C_{captured} = 1.0$  (capture efficiency expressed as fraction)  
 $C_{efficiency} = 0.98$  (control efficiency expressed as fraction)  
2,000 [lb/ton]

Therefore:

$$E_{oil,tanks,VOC} = 1,231,945 \times \frac{0.287}{2,000} \times [1 - 0 - 0 \times 1.0 \times 0.98]$$

$$E_{oil,tanks,VOC} = 177 \text{ [tons-VOC/yr]}$$

Flaring emissions are calculated similarly to the example given above for condensate tanks. In this case, since the fraction of crude oil tank vapors sent to flares is zero, there are no flare emissions.

### **3.6 Dehydrators**

This source category refers to wellhead dehydrator units. Dehydrator units are used to remove excess water from produced natural gas prior to delivery to the pipeline or to a gas processing plant. Two main sources of emissions are found in a dehydrator device: hydrocarbon emissions (including VOC and HAPs) are generated in the dehydrator still vent, and combustion emissions are generated in the dehydrator reboiler. In addition, if dehydrator still vents are controlled by flare, combustion emissions from flaring controls contribute to the total dehydrator emissions. Figure 3-5 shows a glycol dehydrator in the Barnett shale.



**Figure 3-5. Dehydrator**

The basic methodology for estimating county-wide emissions from dehydrator still vents is shown in Equation 15:

Equation 15) 
$$E_{stillventVOC} = P_{gas} \times \frac{EF_{stillvent}}{1,000 \times 2,000} \times [1 - F_{flare} \times C_{captured} \times C_{efficiency}]$$

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where:

$E_{stillvent,VOC}$  is the county-wide VOC emissions from dehydrator still vents [ton/yr]  
 $P_{gas}$  is the annual county-wide gas production [MCF/yr]  
 $EF_{stillvent}$  is the VOC emission factor for dehydrator still vent per unit of gas throughput [lb-VOC/MMCF]  
 $F_{flare}$  is the fraction of dehydrator vents with flares  
 $C_{captured}$  is the capture efficiency of the flare  
 $C_{efficiency}$  is the control efficiency of the flare  
2,000 is the unit conversion factor lb/ton  
1,000 is the unit conversion factor MCF/MMCF

The methodology for estimating dehydrator still vent emissions from other pollutants  $i$  is shown below:

Equation 16) 
$$E_{stillvent,i} = E_{stillvent,VOC} \times \frac{weight\ fraction_i}{weight\ fraction_{VOC}}$$

where:

$E_{stillvent,i}$  is the county-wide emissions of pollutant  $i$  from dehydrator still vents [ton/yr]  
 $E_{stillvent,VOC}$  is the county-wide VOC emissions from dehydrator still vents [ton/yr]  
( $weight\ fraction_i/weight\ fraction_{VOC}$ ) is the mass-based weight fraction of pollutant  $i$  divided by the weight fraction of VOC in the vented gas

The basic methodology for estimating emissions for the dehydrator reboiler is equivalent to that of a standard field heater:

Equation 17) 
$$E_{reboiler,i} = N \times \frac{EF_i \times Q_{reboiler} \times t_{annual} \times hc}{HV \times 2,000} \times W_{gas}$$

where:

$E_{reboiler,i}$  is the county-wide emissions from pollutant  $i$  from dehydrator reboilers [ton/yr]  
 $N$  is the number of dehydrators per well [1/well]  
 $EF_i$  is the emission factor for pollutant  $i$  for natural gas-fired small boilers [lb/MMCF]  
 $Q_{reboiler}$  is the heater size [MMBtu/hr]  
 $t_{annual}$  is the annual hours of operation [hr]  
 $hc$  is a heater cycling fraction of operating hours that the heater is firing  
 $HV$  is the local natural gas heating value [Btu<sub>local</sub>/SCF]  
 $W_{gas}$  is the county-wide number of active gas wells in a particular year [well/yr]  
2,000 is the unit conversion factor lb/ton

### **Flaring emissions from dehydrator venting controls**

The methodology for estimating county-wide emissions from flaring of dehydrator still vent gas is described below:



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Equation 18)

$$E_{flare,dehy,i} = \left( P_{gas} \times Q_{dehydrator,vent} \times F_{flare} \times (C_{captured}) \times (C_{efficiency}) \times \frac{EF_i \times HV}{10^6} \right) / 2,000$$

where:

$E_{flare,dehy,i}$  is the county-wide emissions of pollutant  $i$  from dehydrator vent gas flaring [ton/yr]

$P_{gas}$  is the annual county-wide gas production [MCF/yr]

$Q_{dehydrator,vent}$  is the volume of gas flared per unit of gas throughput in dehydrator [MCF vented/MMCF natural gas]

$F_{flare}$  is the fraction of dehydrators with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

$EF_i$  is the flaring emissions factor for pollutant  $i$  [lb/MMBtu]

$HV$  is the local heating value of the gas [BTU/SCF]

2,000 is the unit conversion factor lb/ton

$10^6$  is the unit conversion factor SCF/MMCF

The methodology for estimating SO<sub>2</sub> emissions from flaring of dehydrator vent gas is shown below:

Equation 19)

$$E_{flare,dehydrator,SO_2} = P \times \left( \frac{P_{gas} \times Q_{dehydrator,vent} \times F_{flare} \times (C_{captured}) \times (C_{efficiency})}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times f_{H_2S} \times 2/907,185$$

where:

$E_{flare,dehydrator,SO_2}$  is the county-wide SO<sub>2</sub> flaring emissions from flaring of dehydrator vent gas [ton/yr]

$P$  is atmospheric pressure [1 atm]

$P_{gas}$  is the annual county-wide gas production [MCF/yr]

$Q_{dehydrator,vent}$  is the volume of gas flared per unit of gas throughput [MCF vented/MMCF natural gas]

$F_{flare}$  is the fraction of dehydrators with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of the dehydrator venting gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$f_{H_2S}$  is the mass fraction of H<sub>2</sub>S in the dehydrator venting gas

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

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### **Extrapolation to county-level emissions**

Equations 15-19 provide direct county-level estimates of pollutant emissions from dehydrator still vents, reboilers, and flaring controls. Emissions of the same pollutant each of these three sub-categories should be added together to arrive at total county-level dehydrator emissions (still vent + reboiler + flaring).

### **Example Calculation for Dehydrators:**

Using the equations provided above, VOC emissions from the still vents and reboilers of dehydrators in Cleburne County, Arkansas were calculated as follows:

Still Vent emissions:

$$E_{stillvent,VOC} = P_{gas} \times \frac{EF_{stillvent}}{1,000 \times 2,000} \times [1 - F_{flare} \times C_{captured} \times C_{efficiency}]$$

where:

$E_{stillvent,VOC}$  is the county-wide VOC emissions from dehydrator still vents [ton/yr]

$P_{gas} = 139,458,888$  [MCF/yr]

$EF_{stillvent} = 0.528$  [lb-VOC/MMCF]

$F_{flare} = 0$  (fraction of dehydrator vents with flares)

$C_{captured} = 1.0$  (capture efficiency expressed as fraction)

$C_{efficiency} = 0.98$  (control efficiency expressed as fraction)

2,000 [lb/ton]

1,000 [MCF/MMCF]

Therefore:

$$E_{stillvent,VOC} = 139,458,888 \times \frac{0.528}{1,000 \times 2,000} \times [1 - 0 \times 1.0 \times 0.98]$$

$$E_{stillvent,VOC} = 36.8 \text{ [ton/yr]}$$

Flaring emissions are calculated similarly to the example given above for condensate tanks. In this case, since the fraction of still vent vapors sent to flares is zero, there are no flare emissions.

Reboiler emissions:

$$E_{reboiler, voc} = N \times \frac{EF_{VOC} \times Q_{reboiler} \times t_{annual} \times hc}{HV \times 2,000} \times W_{gas}$$

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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where:

$E_{reboiler,VOC}$  is the county-wide emissions of VOC from dehydrator reboilers [ton/yr]

$N = 1$  [per well]

$EF_{VOC} = 5.5$  [lb/MMCF]

$Q_{reboiler} = 0.9875$  [MMBtu/hr]

$t_{annual} = 8,672.5$  [hr/yr]

$hc = 1$  (cycling fraction of operating hours that the heater is firing)

$HV = 1,035$  [Btu<sub>local</sub>/SCF]

$W_{gas} = 490$  [wells]

2,000 [lb/ton]

Therefore:

$$E_{reboiler,VOC} = 1 \times \frac{5.5 \times 0.9875 \times 8,672.5 \times 1}{1,035 \times 2,000} \times 490$$

$$E_{reboiler,VOC} = 11.15 \text{ [ton/yr]}$$

Total VOC emissions from dehydrators in Cleburne County can be evaluated as follows:

$$E_{dehy,VOC} = E_{stillvent,VOC} + E_{reboiler,VOC}$$

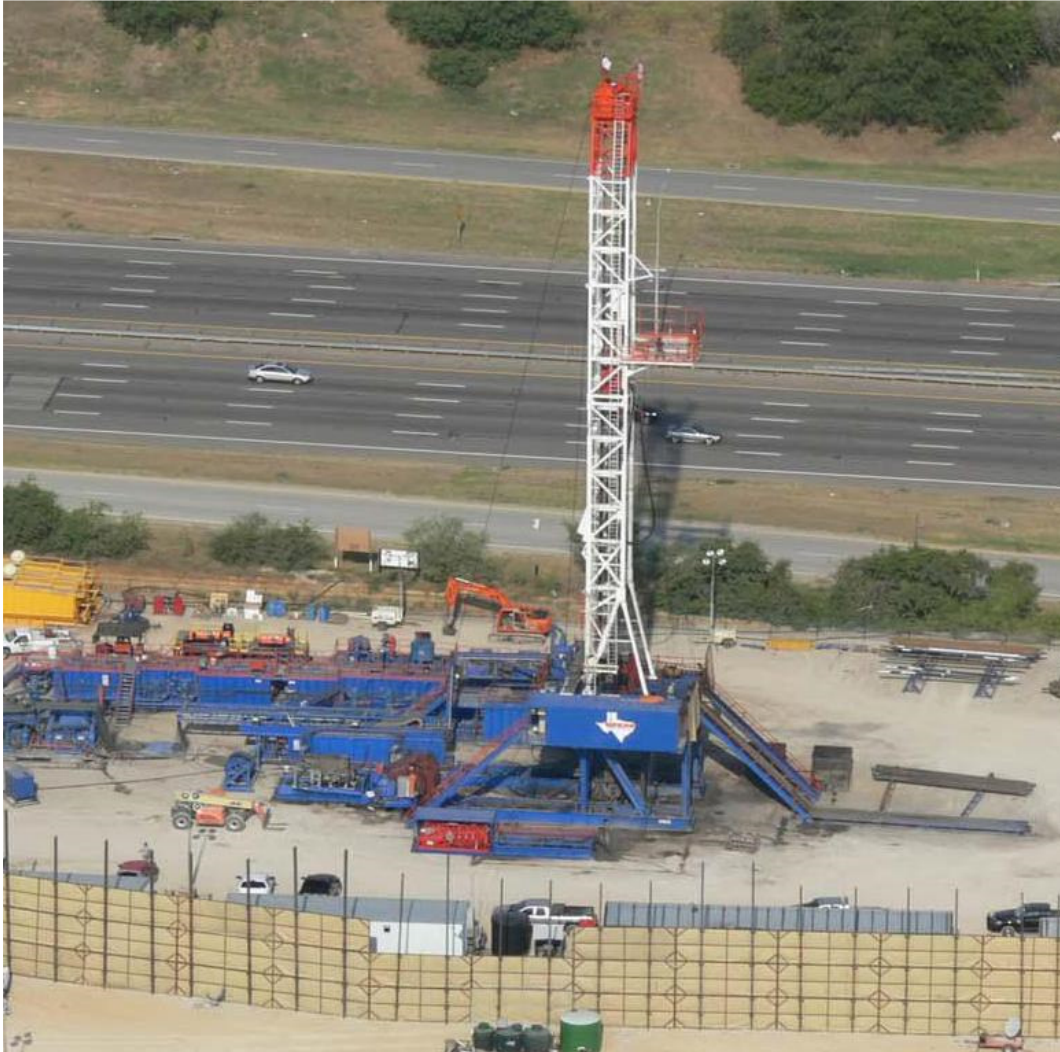
$$E_{dehy,VOC} = 36.8 \text{ [ton/yr]} + 11.15 \text{ [ton/yr]}$$

$$E_{dehy,VOC} = 48.0 \text{ [ton/yr]}$$

### **3.7 Drilling Rigs**

Drilling rig emissions come from three primary engine types: Draw works, Mud pumps and Generators. Each of these three engine types is used for differing periods of time throughout the drilling process and are likely to have different load factor and sizes. Each of the three engines is also likely to be of differing model years and hence Tier levels. Some drilling rigs operate with a set of large generator engines which provides electric power to the other prime movers of the rig – draw works and mud pumps; these type of rigs are referred to here as diesel-electric rigs. Figure 3-6 shows a drilling rig in the Barnett shale.

In order to account for variations in engine characteristics and their effect in final emissions, average emissions for each type of engine  $k$  ( $k$ =drawworks, mud pumps or generators) is estimated separately. In addition, operation parameters such as time and load factor may vary for vertical, directional, and horizontal wellbores; hence emissions are estimated separately for both drilling methods using equations 20 and 21. Directional wells are included with vertical wells for purposes of the calculation.



**Figure 3-6. Drilling Rig**

Emissions for a single engine of type  $k$  are estimated according to Equation 20:

Equation 20) 
$$E_{\text{engine } k,i} = \frac{EF_i \times HP_k \times LF_k \times t_{\text{event}} \times n}{907,185}$$

where:

$E_{\text{engine } k,i}$  are emissions of pollutant  $i$  from an engine type  $k$  [ton/spud]

$EF_i$  is the emissions factor of pollutant  $i$  [g/hp-hr]

$HP_k$  is the horsepower for an engine  $k$  in the county [hp]

$LF_k$  is the load factor of the engine  $k$

$t_{\text{event}}$  is the number of hours engine  $k$  is used [hr/spud]

$n$  is the number of type- $k$  engines in the typical drill rig

907,185 is the mass unit conversion [g/ton]

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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The emission factor for pollutant  $i$ ,  $EF_i$ , is an emissions factor derived from EPA's NONROAD2008 model and based on the representative population of drilling engine of various tier levels in NONROAD. The emissions factor for drill-rig equipment varies by horsepower range, and there are three possible horsepower bins applicable to the typical range of equipment sizes for drill rig engines. Hence, three sets of possible engine emissions factors (by HP) are used.

Emissions from a single drill rig ( $E_{drillrigTOTAL,i}$ ) are estimated in Equation 21 as the sum of individual emissions from each drill rig engine as calculated with Equation 20 in [tons/spud]:

Equation 21) 
$$E_{drillrigTOTAL,i} = \sum E_{engine\ k,i}$$

Two distinct drill-rig configurations may be found in various basins:

- Diesel-mechanical (D) drill rigs: in which all  $k$  engines are diesel-fueled
- Diesel-electric (DE) powered drill rigs: in which only the generator is powered by diesel and the draw works and mud pumps are electric (and thus do not have direct emissions associated with them)

Thus equations 20 and 21 will vary by these two configurations, and a set of input values for each the four combinations of vertical/horizontal wellbores and diesel/diesel-electric rigs must be applied.

Emissions from drill rigs correlate to the depth of the wellbore, which will vary between horizontal and vertical wellbores; thus emissions can be estimated on a “per foot drilled” basis using the equation below.

Equation 22) 
$$[E_{drilling,i}]_{vertical/horizontal} = \left[ \frac{E_{drillrigTOTAL,i_D} \times (1 - F_{DE}) + E_{drillrigTOTAL,i_{DE}} \times F_{DE}}{D_{spud}} \right] \frac{vertical}{horizontal}$$

where

$E_{drilling,i}$  is the total emissions for a horizontal or vertical spud per unit of feet drilled [tons/ft]

$E_{drillrigTOTAL,i_D}$  is the emissions from a single diesel-powered drill rig (from Equation 21) for a vertical or a horizontal spud [tons/spud]

$F_{DE}$  is the fraction of drill rigs that are diesel-electric

$E_{drillrigTOTAL,i_{DE}}$  is the emissions from a single diesel-electric drill rig (from Equation 21) for a vertical or a horizontal spud [tons/spud]

$D_{spud}$  is the depth of a vertical or horizontal spud [ft/spud]

## Nonpoint Oil and Gas Emissions Estimation Tool

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### Extrapolation to county-level emissions

Emissions per feet drilled are scaled to county-level drilling emissions according to Equation 23.

Equation 23)

$$E_{drill, county-wide, i} = [E_{drilling, i}]_{vertical} \times D_{vertical} + [E_{drilling, i}]_{horizontal} \times D_{horizontal}$$

where:

$E_{drill, county-wide, i}$  is the total emissions of pollutant  $i$  from county-wide drilling activity [tons/yr]

$E_{drilling, i}$  is the total emissions from drilling a single well [tons/ft]

$D_{vertical}$  is the total depth drilled in the county for vertical wells in a particular year [ft/yr]

$D_{horizontal}$  is the total depth drilled in the county for horizontal wells in a particular year [ft/yr]

### Example Calculation for Drill Rigs:

Drill rigs are classified as mechanical, or diesel electric. Mechanical rigs typically operate three types of engines during drilling: draw works engines (draw), mud pump engines (mud), and generator engines (gen). Diesel electric rigs are powered by a battery of diesel-electric generator engines. Wells are classified as vertical (a vertical wellbore), directional (a wellbore that is angled or deviates from vertical), and horizontal (after an initial vertical direction, the well is drilled horizontally). No vertical wells were drilled in Cleburne County, and there are no diesel electric rigs. Using the equations provided above, NO<sub>x</sub> emissions from drilling in Cleburne County, Arkansas were calculated as follows:

Emissions from a draw works engine during horizontal drilling:

$$E_{draw works} = \frac{EF \times HP \times LF \times t_{event} \times n}{907,185}$$

where:

$E_{draw works}$  = are emissions of NO<sub>x</sub> from a draw works engine [ton/spud]

$EF = 4.258$  [g/hp-hr]

$HP = 557.5$  [hp]

$LF = 0.4$  (load factor for the engine)

$t_{event} = 200$  [hr/spud]

$n = 2$  (number of draw work engines in the typical drill rig)

907,185 [g/ton]

Therefore:

$$E_{draw works} = \frac{4.258 \times 557.5 \times 0.4 \times 200 \times 2}{907,185}$$

$$E_{draw works} = 0.42 \text{ [ton /spud]}$$

### **Nonpoint Oil and Gas Emissions Estimation Tool**

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Using similar methodology, emissions for mud pump and generator engines during horizontal drilling were calculated to yield:

$$E_{draw\ works} = 0.42 \text{ [ton /spud]}$$

$$E_{mud\ pump} = 0.90 \text{ [ton /spud]}$$

$$E_{generator} = 1.19 \text{ [ton /spud]}$$

Total NO<sub>x</sub> emissions from all drill rig engines per spud can be evaluated as follows:

$$E_{drillrigTOTAL} = \sum E_{engine}$$

$$E_{drillrigTOTAL} = 2.51 \text{ [ton /spud]}$$

Total NO<sub>x</sub> emissions on a per foot basis are then calculated using:

$$[E_{drilling}]_{vertical/horizontal} = \left[ \frac{E_{drillrigTOTAL\ D} \times (1 - F_{DE}) + E_{drillrigTOTAL\ DE} \times F_{DE}}{D_{spud}} \right] \frac{vertical}{horizontal}$$

where

$E_{drilling}$  is the total emissions for a horizontal or vertical spud per unit of feet drilled [tons/ft]

$$E_{drillrigTOTAL, D} = 2.51 \text{ [ton /spud]}$$

$F_{DE} = 0$  (fraction of drill rigs that are diesel-electric)

$$E_{drillrigTOTAL, DE} = 0 \text{ [ton /spud]}$$

$$D_{spud} = 9,318.1 \text{ [ft/spud]}$$

Therefore:

$$E_{drilling, horizontal} = \frac{2.51 \times (1 - 0) + (0 \ 0)}{9,318.1}$$

$$E_{drilling, horizontal} = 0.0002693 \text{ [ton /ft]}$$

Finally, county-wide emissions may be calculated as follows:

$$E_{drill, county-wide} = [E_{drilling}]_{vertical} \times D_{vertical} + [E_{drilling}]_{horizontal} \times D_{horizontal}$$

where:

$E_{drill, county-wide}$  is the total emissions of NO<sub>x</sub> from county-wide drilling activity [ton/yr]

$$E_{drilling, vertical} = 0 \text{ [tons/ft]}$$

$$D_{vertical} = 0 \text{ [ft/yr]}$$

$$E_{drilling, horizontal} = 0.0002693 \text{ [tons/ft]}$$

$$D_{horizontal} = 596,026.5 \text{ [ft/yr]}$$

Therefore:

$$E_{drill, county-wide} = 0.00002693 \times 596,026.5$$

$$E_{drill, county-wide} = 160.55 \text{ [ton /yr]}$$

### 3.8 Fugitive Leaks

This source category refers to leaking emissions of produced gas that escape through well site and pipeline components such as connectors, flanges, open-ended lines, valves, and compressor wet seals. It must be noted that this source category refers only to fugitive emissions components located at the wellhead and that large transmission pipeline fugitives and other midstream fugitives sources are not part of this analysis. Figure 3-7 shows numerous flanges (circled) and a series of separators at a multi-well pad in the Marcellus shale. <sup>1</sup>



**Figure 3-7. Flanges**

Fugitive emissions for an individual typical well are estimated according to Equation 24:

Equation 24) 
$$E_{fugitive, j} = (\sum_i EF_i \times N_i \times t_{annual} \times Y_j) / 907.185$$

where:

$E_{fugitive, j}$  is the fugitive emissions for a single typical well for pollutant  $j$  [ton/yr/well]  
 $EF_i$  is the emission factor of TOC for a single component  $i$  [kg/hr/component]



### **Nonpoint Oil and Gas Emissions Estimation Tool**

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$N_i$  is the total number of components of type  $i$

$t_{annual}$  is the annual number of hours the well is in operation [8760 hr/yr]

$Y_j$  is the mass ratio of pollutant  $j$  to TOC in the vented gas

907.185 is the unit conversion factor kg/ton

In addition, fugitive leaks from wellhead compressor seals can be estimated from the following equations:

$$\text{Equation 25) } E_{compressor, fug, CH_4} = \left( \frac{P \times (V_{vented}) \times t}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{(f_{wellhead} + 1/N_{lateral})}{907,185 \times 1,000} \times W_{gas}$$

where:

$E_{compressor, fug, CH_4}$  is the county-wide CH<sub>4</sub> fugitive emissions from compressor seals [ton/yr]

$P$  is atmospheric pressure [1 atm]

$V_{vented}$  is the volume of leaked methane per compressor [SCF/compressor/hour]

$t$  is the annual hours of operation for wellhead compressors [hrs/yr]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of the pollutant [g/mol]

$T$  is the atmospheric temperature [298 K]

$f_{wellhead}$  is the fraction of wells with wellhead compressors

$N_{lateral}$  is the number of gas wells served by a lateral compressor engine

$W_{gas}$  is the county-wide number of gas wells

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

1,000 is the unit conversion factor SCF/MCF

To estimate emissions of other pollutants (VOC, H<sub>2</sub>S) the following equation may be used:

$$\text{Equation 26) } E_{compressor, fug, i} = E_{compressor, fug, CH_4} \times \frac{MW_i}{MW_{CH_4}} \times \frac{M_i}{M_{CH_4}}$$

where:

$E_{compressor, fug, i}$  is the county-wide compressor fugitive emissions for pollutant  $i$  [ton/yr]

$E_{compressor, fug, CH_4}$  is the compressor fugitive emissions for CH<sub>4</sub> [ton CH<sub>4</sub>/yr]

$MW_i$  is the molecular weight of pollutant  $i$  [lb/lb-mol]

$MW_{CH_4}$  is the molecular weight of CH<sub>4</sub> [lb/lb-mol]

$M_{CH_4}$  is the mole percent of CH<sub>4</sub> in the local gas [%]

$M_i$  is the mole percent of pollutant in the local gas [%]

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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### **Extrapolation to county-level emissions**

County-wide fugitive emissions from well-site piping components are estimated according to Equation 27:

$$\text{Equation 27)} \quad E_{fugitive, TOTAL} = E_{fugitive, j} \times N_{well}$$

where:

$E_{fugitive, TOTAL}$  is the total fugitive emissions from well-site piping components in the county [ton/yr]

$E_{fugitive, j}$  is the fugitive emissions for a single well of pollutant  $j$  [ton/yr/well] (from Equation 24)

$N_{well}$  is the total number of active wells in the county [wells]

Total county-wide fugitive emissions are the sum of compressor seal emissions and component fugitive emissions.

### **Example Calculation for Fugitive Leaks:**

Fugitive emissions at gas well and oil well sites occur from connectors, flanges, open-ended lines, compressor seals, and valves. Using the equations provided above, VOC emissions for fugitive leaks from valves at gas wells in Cleburne County, Arkansas were calculated as follows:

$$E_{fugitive} = \left( \sum_i EF \times N \times t_{annual} \times Y \right) / 907.185$$

where:

$E_{fugitive}$  is the VOC emissions for a single gas well from valves [ton/yr/well]

$EF = 0.0045$  [kg TOC/hr/valve]

$N = 12$  [valves/well]

$t_{annual} = 8,760$  [hr/yr]

$Y = 0.036$  [VOC to TOC ratio]

907.185 [kg/ton]

Therefore:

$$E_{fugitive} = (0.0045 \times 12 \times 8,760 \times 0.036) / 907.185$$

$$E_{fugitive} = 0.0188 \text{ [ton/well]}$$

Total VOC emissions from fugitive leaks from valves at gas wells in Cleburne County were calculated as follows:

### Nonpoint Oil and Gas Emissions Estimation Tool

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$$E_{fugitive,TOTAL} = E_{fugitive} \times N_{well}$$

where:

$E_{fugitive,TOTAL}$  is the total fugitive emissions from valves in Cleburne County [ton/yr]

$E_{fugitive} = 0.0188$  [ton/yr/well]

$N_{well} = 490$  [wells]

Therefore:

$$E_{fugitive,TOTAL} = 0.0188 \times 490$$

$$E_{fugitive,TOTAL} = 9.21 \text{ [ton/yr]}$$

### 3.9 Gas-Actuated Pumps

Gas-actuated pumps refer to small gas-driven plunger pumps used at oil and gas production sites, to provide a constant supply of chemicals or lubricants to specific flow lines or equipment. These are regularly used in sites where electric power is unavailable. As part of their operation, gas-driven pumps vent part of the driving gas to the atmosphere, making them a VOC and CH<sub>4</sub> emissions source. Two types of gas-actuated pumps were considered: Kimray pumps and chemical injection pumps (CIP). For oil wells only CIPs are assumed to be used. Annual vented gas rates per well from Kimray pumps are estimated following Equation 28:

$$\text{Equation 28)} \quad E_{kimray,CH_4} = \frac{EF_{CH_4}}{907,185} \times Q_{kimray} \times \frac{P}{1,000 \times \left( \left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5} \right)}$$

where:

$E_{kimray,CH_4}$  is the per-well CH<sub>4</sub> emissions from Kimray pumps [tons- CH<sub>4</sub>/well-yr]

$EF_{CH_4}$  is the CH<sub>4</sub> emissions factor for a Kimray pump per unit throughput [SCF-CH<sub>4</sub>/MMCF]

$Q_{kimray}$  is the gas pumped per well annually with Kimray pumps [MMCF/well-yr]

$P$  is the atmospheric pressure [1 atm]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of CH<sub>4</sub> [g/mol]

$T$  is the atmospheric temperature [298 K]

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

1,000 is the unit conversion factor SCF/MCF

### Nonpoint Oil and Gas Emissions Estimation Tool

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Emissions from CIPs are estimated based on Equation 29:

Equation 29) 
$$E_{CIP,CH_4} = \frac{EF_{CH_4}}{907,185} \times N_{CIP} \times \frac{t_{CIP}}{24} \times \frac{P}{1,000 \times \left( \left( \frac{R}{MW_{CH_4}} \right) \times T \times 3.5 \times 10^{-5} \right)}$$

where:

$E_{CIP,CH_4}$  is the per-well CH<sub>4</sub> emissions from CIP pumps [tons- CH<sub>4</sub>/well-yr]

$EF_{CH_4}$  is the CH<sub>4</sub> emissions factor for a CIP pump [SCF- CH<sub>4</sub>/pump/day]

$N_{CIP}$  is the number of CIPs per well [pump/well]

$t_{CIP}$  is the regular operation time for chemical injection pumps [hrs/yr]

$P$  is the atmospheric pressure [1 atm]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{CH_4}$  is the molecular weight of CH<sub>4</sub> [g/mol]

$T$  is the atmospheric temperature [298 K]

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

1,000 is the unit conversion factor SCF/MCF

To estimate emissions from other pollutants (VOC, CO<sub>2</sub>, H<sub>2</sub>S, HAPs) from Kimray and CIP pumps, the following equation may be used:

Equation 30) 
$$E_{pump,i} = E_{pump,CH_4} \times \frac{MW_i}{MW_{CH_4}} \times \frac{M_i}{M_{CH_4}}$$

where:

$E_{pump,i}$  is the emissions for pollutant  $i$  per well from CIPs or Kimray Pumps [ton/well-yr]

$E_{pump,CH_4}$  is the CH<sub>4</sub> emissions from CIPs or Kimray Pumps [ton CH<sub>4</sub>/well-yr] (from Equations 28 or 29)

$MW_i$  is the molecular weight of pollutant  $i$  [lb/lb-mol]

$MW_{CH_4}$  is the molecular weight of CH<sub>4</sub> [lb/lb-mol]

$M_{CH_4}$  is the mole percent of CH<sub>4</sub> in the local gas vented from the pump [%]

$M_i$  is the mole percent of pollutant  $i$  in the local gas vented from the pump [%]

### Extrapolation to county-level emissions

To estimate county-wide annual emissions from gas-actuated pumps for each pollutant, the scaling surrogate used is well counts, according to Equation 31:

Equation 31)

$$E_{GAP, i} = [(E_{CIP, i} + E_{kimray,i}) \times W_{gas}]_{gas\ wells} + [E_{CIP, i} \times W_{oil}]_{oil\ wells}$$

### Nonpoint Oil and Gas Emissions Estimation Tool

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where:

- $E_{GAP, i}$  is the annual county-wide emissions for pollutant  $i$  from gas-actuated pumps [ton/yr]
- $E_{CIP, i}$  is the emissions from chemical injection pumps per well type (gas or oil) [ton/yr-well]
- $E_{kimray, i}$  is the emissions from kimray pumps per well [ton/yr-well]
- $W_{gas}$  is the number of active gas wells in a particular county [wells]
- $W_{oil}$  is the number of active oil wells in a particular county [wells]

#### Example Calculation for Gas-Actuated Pumps:

Using the equations provided above, VOC emissions for gas-actuated pumps in Cleburne County, Arkansas were calculated as follows:

#### Kimray Pumps

$$E_{kimray, CH_4} = \frac{EF_{CH_4}}{907,185} \times Q_{kimray} \times \frac{P}{1,000 \times \left( \left( \frac{R}{MW_{CH_4}} \right) \times T \times 3.5 \times 10^{-5} \right)}$$

where:

- $E_{kimray, CH_4}$  is the per-well  $CH_4$  emissions from Kimray pumps at gas wells [tons- $CH_4$ /well-yr]
- $EF_{CH_4} = 1,041$  [SCF-  $CH_4$ /MMCF]
- $Q_{kimray} = 42.9$  [MMCF/well-yr]
- $P = 1$  [atm]
- $R = 0.082$  [L-atm/mol-K]
- $MW_{CH_4} = 16.04$  [g/mol]
- $T = 298$  [K]
- 907,185 [g/ton]
- 1,000 [SCF/MCF]
- $3.5 \times 10^{-5}$  [MCF/L]

Therefore:

$$E_{kimray, CH_4} = \frac{1,041}{907,185} \times 42.9 \times \frac{1}{1,000 \times \left( \left( \frac{0.082}{16.04} \right) \times 298 \times 3.5 \times 10^{-5} \right)}$$

$$E_{kimray, CH_4} = 0.923 \text{ [tons } CH_4/\text{well/yr]}$$

VOC emissions are then calculated using:

$$E_{kimray} = E_{kimray, CH_4} \times \frac{MW_{VOC}}{MW_{CH_4}} \times \frac{M_{VOC}}{M_{CH_4}}$$

where:

- $E_{kimray}$  is the emissions of VOC per well from Kimray Pumps [ton/well-yr]
- $EF_{kimray, CH_4} = 0.923$  [ton  $CH_4$ /well-yr]
- $MW_{VOC} = 52.1$  [lb/lb-mol]

### Nonpoint Oil and Gas Emissions Estimation Tool

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$$MW_{CH_4} = 16.04 \text{ [lb/lb-mol]}$$

$$M_{CH_4} = 0.94 \text{ [percent CH}_4\text{, expressed as a fraction]}$$

$$M_{VOC} = 0.01 \text{ [percent VOC, expressed as a fraction]}$$

Therefore:

$$E_{kimray} = 0.923 \times \frac{52.1}{16.04} \times \frac{0.01}{0.94}$$

$$E_{kimray} = 0.032 \text{ [ton/well-yr]}$$

### Chemical Injection Pumps

$$E_{CIP, CH_4} = \frac{EF_{CH_4}}{907,185} \times N_{CIP} \times \frac{t_{CIP}}{24} \times \frac{P}{1,000 \times \left( \left( \frac{R}{MW_{CH_4}} \right) \times T \times 3.5 \times 10^{-5} \right)}$$

where:

$E_{CIP, CH_4}$  is the per-well CH<sub>4</sub> emissions from CIP pumps at gas wells [tons- CH<sub>4</sub>/well-yr]

$EF_{CH_4} = 260$  [SCF- CH<sub>4</sub>/pump/day]

$N_{CIP} = 0.142$  [pump/well]

$t_{CIP} = 8,760$  [hrs/yr]

$P = 1$  [atm]

$R = 0.082$  [L-atm/mol-K]

$MW_{CH_4} = 16.04$  [g/mol]

$T = 298$  [K]

907,185 [g/ton]

1,000 [SCF/MCF]

$3.5 \times 10^{-5}$  [MCF/L]

Therefore:

$$E_{CIP, CH_4} = \frac{260}{907,185} \times 0.142 \times \frac{8,760}{24} \times \frac{P}{1,000 \times \left( \left( \frac{0.082}{16.04} \right) \times 298 \times 3.5 \times 10^{-5} \right)}$$

$$E_{CIP, CH_4} = 0.279 \text{ [tons CH}_4\text{/well/yr]}$$

Using the same methodology as above for Kimray pumps, VOC emissions from CIP pumps are estimated as:

$$E_{CIP} = 0.011 \text{ [ton/well/yr]}$$

Total VOC emissions from all gas-actuated pumps in Cleburne County can be evaluated as follows:

$$E_{GAP} = [(E_{CIP} + E_{kimray}) \times W_{gas}]_{gas\ wells} + [E_{CIP} \times W_{oil}]_{oil\ wells}$$

where:

$E_{GAP}$  is the annual county-wide VOC emissions from gas-actuated pumps [ton/yr]

$E_{CIP} = 0.011$  [ton/yr-well]

$E_{kimray} = 0.032$  [ton/yr-well]

$W_{gas} = 490$  [wells]

$W_{oil} = 0$  [wells]

Therefore:

$$E_{GAP} = [(0.011 + 0.032) \times 490]_{gas\ wells} + [0.011 \times 0]_{oil\ wells}$$

$$E_{GAP} = 21.1 \text{ [ton/yr]}$$

### **3.10 Heaters**

This category refers to natural gas-fired external combustors used in oil and gas production facilities to provide heat input to separators (separator heaters or heater treaters), to prevent the formation of hydrates during pressure reductions (line heaters), or to provide heat to tanks (tank heaters). This category does not refer to reboilers used in dehydrators as those emissions are captured in the dehydrator source category. Figure 3-8 shows a line heater at a natural gas well in the Marcellus shale.<sup>1</sup>



**Figure 3-8. Line Heater**

The basic methodology for estimating emissions for all pollutants except SO<sub>2</sub> for a single heater is shown in Equation 32. Local fuel gas properties will vary between gas wells and oil wells; hence emissions are estimated separately for this category. Due to limited field data for this category, all other parameters unrelated to local gas composition were assumed to be the same for gas and oil wells.

Equation 32) 
$$E_{heater} = \frac{EF_{heater} \times Q_{heater} \times t_{annual} \times hc}{(HV \times 2,000)}$$

where:

$E_{heater}$  is the emissions from a given heater [ton/yr]

$EF_{heater}$  is the emission factor for a heater for a given pollutant [lb/million SCF]

$Q_{heater}$  is the heater MMBTU/hr rating [MMBTU<sub>rated</sub>/hr]

$t_{annual}$  is the annual hours of operation [hr/yr]

$hc$  is a heater cycling fraction to account for the fraction of operating hours that the heater is firing (if not available,  $hc=1$ )

$HV$  is the local natural gas heating value [BTU<sub>local</sub>/SCF]

2,000 is the unit conversion factor lb/ton



## Nonpoint Oil and Gas Emissions Estimation Tool

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The methodology for estimating SO<sub>2</sub> emissions from heaters requires first estimating the mass of gas combusted in the heater, and then uses the mass fraction of H<sub>2</sub>S in the gas and the assumption that all H<sub>2</sub>S is converted to SO<sub>2</sub>. This methodology is described in Equation 33.

$$\text{Equation 33)} \quad E_{heater,SO_2} = \frac{2 \times f_{H_2S}}{907,185} \times \left( \frac{Q_{heater} \times t_{annual} \times hc}{(HV)} \times \frac{P}{\left( \left( \frac{R}{MW_{gas}} \right) \times T \times 0.035 \right)} \right)$$

where:

$E_{heater,SO_2}$  is the SO<sub>2</sub> emissions from a given heater [ton-SO<sub>2</sub>/yr]

$f_{H_2S}$  is the mass fraction of H<sub>2</sub>S in the gas

$Q_{heater}$  is the heater MMBTU/hr rating [MMBTU<sub>rated</sub>/hr]

$t_{annual}$  is the annual hours of operation [hr/yr]

$hc$  is a heater cycling fraction to account for the fraction of operating hours that the heater is firing

$HV$  is the local natural gas heating value [MMBTU<sub>local</sub>/scf]

$P$  is atmospheric pressure [1 atm]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of the gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$3.5 \times 10^{-3}$  is the unit conversion factor SCF/L

907,185 is the unit conversion factor g/ton

1,000 is the unit conversion factor SCF/MCF

### Extrapolation to county-level emissions

County-wide heater emissions are estimated by determining the typical number of heaters per well and scaling up by well count. This is shown in Equation 34:

$$\text{Equation 34)} \quad E_{heater,TOTAL} = E_{heater} \times N_{heater} \times W_{TOTAL}$$

where:

$E_{heater,TOTAL}$  is the total heater emissions in a county for a specific pollutant [ton/yr]

$E_{heater}$  is the total emissions from a single heater for a specific pollutant [ton/yr]

$N_{heater}$  is the typical number of heaters per well throughout in the county

$W_{TOTAL}$  is the total number of wells in the county

### Example Calculation for Heaters - Gas:

### **Nonpoint Oil and Gas Emissions Estimation Tool**

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Using the equations provided above, NO<sub>x</sub> emissions from heaters at gas wells in Cleburne County, Arkansas were calculated as follows:

$$E_{heater} = \frac{EF_{heater} \times Q_{heater} \times t_{annual} \times hc}{(HV \times 2,000)}$$

where:

$E_{heater}$  = emissions from a single heater [ton /yr]

$EF_{heater}$  = 100 [lb NO<sub>x</sub>/MMCF]

$Q_{heater}$  = 0.61 [MMBtu/hr]

$t_{annual}$  = 8,760 [hr/yr]

$hc$  = 1 (heater cycling fraction of operating hours that the heater is firing)

$HV$  = 1,035 [MMBtu/MMCF]

2,000 [lb/ton]

Therefore:

$$E_{heater} = \frac{100 \times 0.61 \times 8,760 \times 1}{(1,035 \times 2,000)}$$

$$E_{heater} = 0.258 \text{ [ton/heater/yr]}$$

Total NO<sub>x</sub> emissions from all heaters in Cleburne County can be evaluated as follows:

$$E_{heater, TOTAL} = E_{heater} \times N_{heater} \times W_{TOTAL}$$

where:

$E_{heater, TOTAL}$  = total emissions from heaters [ton/yr]

$E_{heater}$  = 0.258 [ton/heater/yr]

$N_{heater}$  = 0.5 [heaters/well]

$W_{TOTAL}$  = 490 [wells]

Therefore:

$$E_{heater, TOTAL} = 0.258 \times 0.5 \times 490$$

$$E_{heater, TOTAL} = 63.21 \text{ [ton/yr]}$$

### **3.11 Hydraulic Fracturing Pumps**

This category refers to equipment used in hydraulic fracturing practices during well completions and recompletions, generally related to unconventional oil and gas production such as shale gas and tight sands oil/gas. Engines used during hydraulic fracturing are generally large diesel-fueled pumps that can be a significant NO<sub>x</sub> emissions source. Figure 3-9 shows hydraulic fracturing of three wells in the Marcellus shale.<sup>1</sup> The hydraulic fracturing pump engines are lined up on the red tractor trailer rigs.



**Figure 3-9. Hydraulic Fracturing**

Average emissions factors for hydraulic fracturing engines were derived from EPA's NONROAD2008 model based on the oil equipment source category bin in NONROAD. The basic methodology for estimating exhaust emissions from engines used at a hydraulic fracturing event is shown below:

Equation 35) 
$$E_{fracing,event,i} = n \times \frac{EF_i \times HP \times LF \times N_{stages} \times t_{stage}}{907,185}$$

where:

- $E_{fracing,event}$  is the exhaust emissions for pollutant  $i$  from a single fracing event [ton/event]
- $n$  is the number of engines used per fracing event
- $EF_i$  is the emissions factor of pollutant  $i$  [g/hp-hr]
- $HP$  is the horsepower of the engine [hp]
- $LF$  is the load factor of the engine
- $N_{stages}$  is the number of stages per fracing event [stage/event]
- $t_{stage}$  is the duration of the fracturing stage [hr/stage]
- 907,185 is the unit conversion factor g/ton

#### Extrapolation to county-level emissions

Fracing pump emissions can be scaled up to the county level on the basis of horizontal spuds. It is assumed that hydraulic fracturing is performed in all horizontal spuds and thus the

### Nonpoint Oil and Gas Emissions Estimation Tool

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methodology for scaling up fracturing pump engine emissions is based on this surrogate as shown below:

Equation 36) 
$$E_{frac,pumps,TOTAL} = N_{events} \times E_{fracing,event}$$

where:

$E_{frac,pump,TOTAL}$  is the total emissions from fracing pump engines in the county [ton/yr]  
 $N_{events}$  is the number of unconventional well completions in a particular year [spuds/yr]  
 $E_{fracing,event}$  is the total exhaust emissions from engines in a single fracing event [ton/event]

#### Example Calculation for Hydraulic Fracturing Pumps:

Using the equations provided above, NO<sub>x</sub> emissions from hydraulic fracturing pumps in Cleburne County, Arkansas were calculated as follows:

$$E_{fracing,event,i} = n \times \frac{EF_i \times HP \times LF \times N_{stages} \times t_{stage}}{907,185}$$

where:

$E_{fracing,event,i}$  = emissions from a single fracturing event [ton/event]  
 $n = 8.5$  [engines/event]  
 $EF = 5.831$  [g/hp-hr]  
 $HP = 2,033$  [hp]  
 $LF = 0.688$  (load factor for the engine)  
 $N_{stages} = 10.5$  [stages/event]  
 $t_{stage} = 2.25$  [hr/stage]  
 $907,185$  [g/ton]

Therefore:

$$E_{fracing} = 8.5 \times \frac{5.831 \times 2,033 \times 0.688 \times 10.5 \times 2.25}{907,185}$$

$$E_{fracing} = 1.81 \text{ [ton/event]}$$

Total NO<sub>x</sub> emissions from all hydraulic fracturing pumps in Cleburne County can be evaluated as follows:

$$E_{fracing,TOTAL} = E_{fracing} \times N_{events}$$

where:

$E_{fracing,TOTAL}$  = total emissions from hydraulic fracturing pumps in a county [ton/yr]  
 $E_{fracing} = 1.81$  [ton/event]  
 $N_{events} = 133$  [spuds/yr]

Therefore:

$$E_{fracing, TOTAL} = 1.81 \times 133$$

$$E_{fracing, TOTAL} = 241 \text{ [ton/yr]}$$

### **3.12 Lateral/Gathering Compressor Engines**

Lateral compressor engines are used to gather gas from multiple individual wells, generally serving groups of approximately 10 to 100 wells. These engines are generally medium size and larger than wellhead compressor engines, but often not large enough to trigger Title V or other major source permitting requirements. Lateral compressor engines were categorized into two main categories and thus emissions are estimated for each type of engine and consequently extrapolated to county-wide emissions. These categories of compressors are:

- Rich burn compressors
- Lean burn compressors

Figure 3-10 shows a large, lateral compressor engine operating in the Barnett shale.



**Figure 3-10. Lateral Compressor Engine**

The basic methodology for estimating emissions from lateral compressor engines is shown in Equation 37:

$$\text{Equation 37)} \quad E_{engine, type} = \frac{EF_i \times HP \times LF \times t_{annual}}{907,185} \times (1 - F_{controlled} \times CF_i)$$

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where:

$E_{engine,type}$  are emissions from a particular type (rich vs. lean) of compressor engine [ton/yr/engine]  
 $EF_i$  is the emissions factor of pollutant  $i$  [g/hp-hr] (note that this value may be differ between rich-burn vs. lean-burn engines)  
 $HP$  is the horsepower of the engine [hp]  
 $LF$  is the load factor of the engine  
 $t_{annual}$  is the annual number of hours the engine is used [hr/yr]  
 $F_{controlled}$  is the fraction of lateral compressors of a particular type that are controlled  
 $CF_i$  is the control factor for controlled engines for pollutant  $i$   
907,185 is the unit conversion factor g/ton

#### Extrapolation to county-level emissions

County-level emissions are represented by a mix of the two types of lateral compressors. Single engine emissions are scaled to county level using the fraction ( $F$ ) of these engine types to total engines, the fraction of wells served by lateral compressor engines, and the total gas well count in a county, according to equation below:

$$\text{Equation 38)} \quad E_{engine,TOTAL} = (F_{rich} E_{engine,rich} + F_{lean} E_{engine,lean}) \times W_{gas} \times \frac{1}{N_{lateral}}$$

where:

$E_{engine,TOTAL}$  is the total emissions from lateral compressor engines in a county [ton/yr]  
 $F_{rich}$  is the fraction of rich-burn lateral compressors in the county amongst all lateral compressors  
 $E_{engine,rich}$  is the total emissions from a single rich burn compressor engine per Equation (37) [ton/yr]  
 $F_{lean}$  is the fraction of lean-burn lateral compressors in the county amongst all lateral compressors  
 $E_{engine,lean}$  is the total emissions from a single lean burn compressor engine per Equation (37) [ton/yr]  
 $W_{gas}$  is the total gas well count in a county  
 $N_{lateral}$  is the number of gas wells served by a lateral compressor engine

#### Example Calculation for Rich-Burn Lateral Compressor:

Using the equations provided above, NO<sub>x</sub> emissions from rich-burn lateral compressor engines in Cleburne County, Arkansas were calculated as follows:

$$E_{engine,rich} = \frac{EF \times HP \times LF \times t_{annual}}{907,185} \times (1 - F_{controlled} \times CF)$$

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where:

$E_{engine, rich}$  = emissions from a rich-burn lateral compressor engine [ton/yr/engine]

$EF = 8.24$  [g/hp-hr]

$HP = 97.0$  [hp]

$LF = 0.74$  (load factor for the engine)

$t_{annual} = 8,760$  [hr/yr]

$F_{controlled} = 0.44$  (fraction controlled)

$CF = 0.90$  (control factor)

907,185 [g/ton]

Therefore:

$$E_{engine, rich} = \frac{8.24 \times 97.0 \times 0.74 \times 8,760}{907,185} \times (1 - 0.44 \times 0.90)$$

$$E_{engine, rich} = 3.45 \text{ [ton/yr/engine]}$$

Total NO<sub>x</sub> emissions from all rich-burn lateral compressor engines in Cleburne County can be evaluated as follows:

$$E_{engine, rich, TOTAL} = (F_{rich} \times E_{engine, rich}) \times W_{gas} \times \frac{1}{N_{lateral}}$$

where:

$E_{engine, rich, TOTAL}$  = total emissions from rich-burn lateral compressor engines in a county [ton/yr]

$F_{rich} = 0.490$  (fraction of rich burn engines)

$E_{engine, rich} = 3.45$  [ton/yr/engine]

$W_{gas} = 490$  [wells]

$N_{lateral} = 32.05$  (number of gas wells served by a lateral compressor engine)

Therefore:

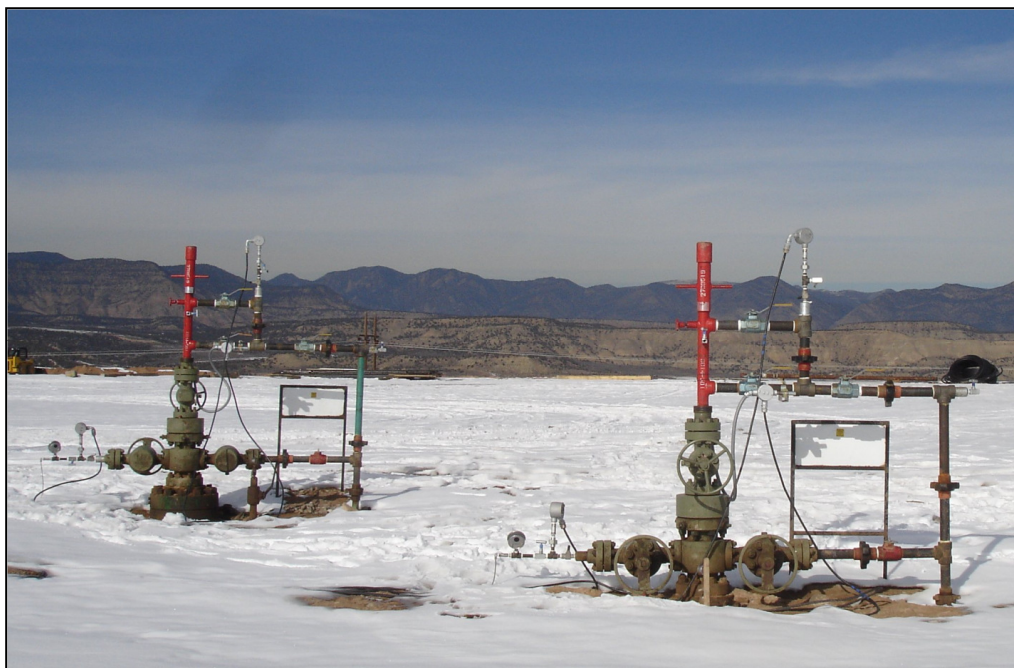
$$E_{engine, rich, TOTAL} = (0.490 \times 3.45) \times 490 \times \frac{1}{32.05}$$

$$E_{engine, rich, TOTAL} = 25.8 \text{ [ton/yr]}$$

### **3.13 Liquids Unloading**

This source category refers to emissions from venting gas from gas wells to prevent liquid build-up in the well that could limit production. This practice is also commonly referred as “well blowdowns”. Vented gas from liquids unloading is a VOC emissions source. Some wells use plunger lifts for liquids unloading, which can also result in vented emissions. Liquids unloading emissions may be controlled by a combustion device such as a flare, or may also be

controlled by a variety of devices and practices that reduce venting from the liquids unloading. Figure 3-11 shows 2 wells equipped with plunger lifts.<sup>3</sup>



**Figure 3-11. Plunger Lifts**

Emissions from liquids unloading are based on the average venting volume per liquids unloading and the gas composition of the vented gas. The calculation methodology for estimating emissions from a single liquids unloading event is shown below in Equation 39:

$$\text{Equation 39)} \quad E_{\text{liquids unloading},i} = \left( \frac{P \times (V_{\text{vented}})}{\left( \frac{R}{MW_{\text{gas}}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{f_i}{907,185}$$

where:

$E_{\text{liquids unloading},i}$  is the emissions of pollutant  $i$  from a single liquids unloading event [ton/event]

$P$  is atmospheric pressure [1 atm]

$V_{\text{vented}}$  is the volume of vented gas per liquids unloading [MCF/event]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{\text{gas}}$  is the molecular weight of the gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$f_i$  is the mass fraction of pollutant  $i$  in the vented gas

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<sup>3</sup> Artificial Lift R&D Council, 2014. Internet address: <http://www.alrdc.org/production/>



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$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

#### **Emissions from flare controls for liquids unloading vents**

In areas where flaring is used to control liquids unloading vents, the methodology for estimating flaring emissions is described below:

Equation 40)

$$E_{flare, liquidsunloading} = \left( \frac{EF_i \times V_{vented} \times F \times (C_{captured}) \times (C_{efficiency}) \times HV}{1,000} \times W_{gas} \times N_{blowdown} \right) / 2,000$$

where:

$E_{flare, liquidsunloading}$  is the county-wide flaring emissions of pollutant  $i$  for liquids unloading [ton/yr]

$EF_i$  is the flaring emissions factor for pollutant  $i$  [lb/MMBtu]

$V_{vented}$  is the volume of vented gas per liquids unloading [MCF/event]

$F$  is the fraction of well liquids unloading that are flared

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

$HV$  is the local heating value of the gas [BTU/SCF]

$W_{gas}$  is the county-wide number of active gas wells for a particular year [wells]

$N_{blowdown}$  the number of annual blowdowns per well in the county [event/yr-well]

1,000 is the unit conversion factor MCF/MMCF

2,000 is the unit conversion factor lb/ton

The methodology for estimating SO<sub>2</sub> emissions from flaring of liquids unloading gas is shown below:

Equation 41)

$$E_{flare, liquidsunloading, SO_2} = \left( \frac{P \times (V_{vented} \times W_{gas} \times N_{blowdown}) \times F \times (C_{captured}) \times (C_{efficiency})}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times f_{H_2S} \times \frac{2}{907,185}$$

where:

$E_{flare, liquidsunloading, SO_2}$  is the county-wide SO<sub>2</sub> flaring emissions from flaring of liquids unloading vent gas [ton/yr]

$P$  is atmospheric pressure [1 atm]

$V_{vented}$  is the volume of vented gas per liquids unloading [MCF/event]

$W_{gas}$  is the county-wide number of gas wells [wells]

$N_{blowdown}$  the number of annual blowdowns per well in the county [event/yr-well]

$F$  is the fraction of liquids unloading with flares

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$C_{\text{captured}}$  is the capture efficiency of the flare

$C_{\text{efficiency}}$  is the control efficiency of the flare

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{\text{gas}}$  is the molecular weight of the liquids unloading gas [g/mol]

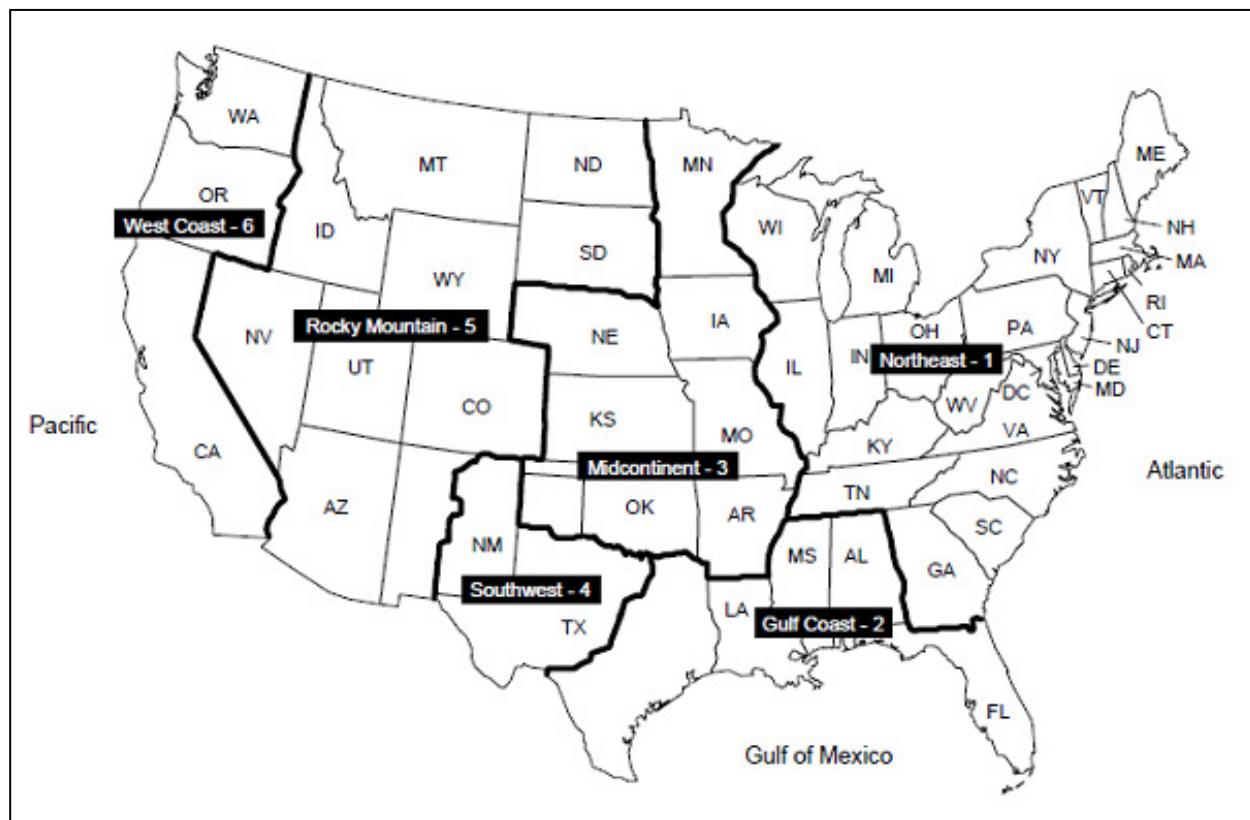
$T$  is the atmospheric temperature [298 K]

$f_{\text{H}_2\text{S}}$  is the mass fraction of  $\text{H}_2\text{S}$  in the liquids unloading venting gas

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

The U.S. Inventory of Greenhouse Gas Emissions and Sinks (U.S. GHG Inventory) was updated in 2014 to reflect newly available data on emissions from liquids unloading.<sup>4</sup> Specifically, EPA analyzed a report issued in September of 2012 by the American Petroleum Institute (API) and America's Natural Gas Alliance (ANGA) entitled "Characterizing Pivotal Sources of Methane Emissions from Natural Gas Production". Using data presented in the report, EPA developed updated vent rates ( $V_{\text{vented}}$  in Equation 40) for liquids unloading activities based on U.S. EIA Supply Regions. Figure 3-12 below shows the six EIA Supply Regions used in the U.S. GHG Inventory.



<sup>4</sup> U.S. EPA, 2013. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013. Internet address: <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html>

**Figure 3-12. EIA Supply Region Map**

Table 3-2 below shows the vent rates ( $V_{vented}$  in Equation 40) by EIA Supply Region for each venting scenario used in the U.S. GHG Inventory.

**Table 3-2. Liquids Unloading Vent Rates from the U.S. GHG Inventory**

EIA Supply Region	Wells venting with plunger lift (%)	Wells venting without plunger lift (%)	Vent Rate for Wells with Plunger Lift (scf/yr/well) <sup>a</sup>	Vent Rate for Wells without Plunger Lift (scf/yr/well) <sup>a</sup>
North East	4.3	11.26	314,626	166,174
Midcontinent	2.33	4.14	1,379,958	230,199
Rocky Mountain	12.88	1.52	154,300	2,579,444
South West	3.32	19.47	3,547	96,748
West Coast	7.59	6.80	345,343	304,048
Gulf Coast	2.32	7.08	70,021	300,592

<sup>a</sup> Whole gas vent rates.

In order to utilize this information within the structure and methodology used in the tool, a weighted vent rate was developed for all wells in a county. Calculation of a weighted vent rate was accomplished using the data in Table 3-2. For example, the updated default liquids unloading vent rate for the North East EIA Supply Region is calculated as follows (using the 2011 value of 153,773 wells in the North East as shown in Table 3-3):

$$E_{liquids\_unloading} = 32,421 \text{ (scf/yr/well)}$$

Table 3-3 shows the resultant default vent rates used in the tool (data from the West Coast Region has been used for the State of Alaska). As these are annual vent rates, where this information is used in the tool, the frequency of liquids unloading venting has been set equal to one event per year. Additionally, as these rates reflect some level of control (through the use of plunger lifts), where this information is used in the tool, a value of “NA” is used for the control method, and no additional reduction from use of controls has been applied.

**Table 3-3. Default Liquids Unloading Vent Rates for the Tool**

EIA Supply Region	Gas Well Count	Default Vent Rate for all Wells (scf/yr/well)
North East	153,773	32,421
Midcontinent	87,193	41,659
Rocky Mountain	58,285	59,047
South West	41,919	18,956

**Table 3-3. Default Liquids Unloading Vent Rates for the Tool**

EIA Supply Region	Gas Well Count	Default Vent Rate for all Wells (scf/yr/well)
West Coast	1,516	46,884
Gulf Coast	71,629	22,913

Extrapolation to county-level emissions

The total county-level emissions from all liquids unloading are evaluated following Equation 42:

$$\text{Equation 42)} \quad E_{\text{liquidsunloading,TOTAL}} = E_{\text{liquidsunloading,i}} \times N_{\text{blowdowns}} \times W_{\text{gas}} \times (1 - F_{\text{control,device}} \times C_{\text{efficiency}})$$

where:

$E_{\text{liquidsunloading,TOTAL}}$  are the total county-wide emissions of pollutant i from liquids unloading [tons/yr]

$E_{\text{liquidsunloading,i}}$  are the liquids unloading emissions from a single liquids unloading event [tons/event]

$N_{\text{blowdowns}}$  is the number of annual blowdowns per well in the county [event/yr-well]

$W_{\text{gas}}$  is the total number of active gas wells in the county for a particular year [well]

$F_{\text{control,device}}$  is the fraction of liquids unloading in the county that were controlled

$C_{\text{efficiency}}$  is the control efficiency of the control technology used (plunger lifts for example)

Example Calculation for Liquids Unloading:

Using the equations provided above, VOC emissions from liquids unloading in Cleburne County, Arkansas were calculated as follows:

$$E_{\text{liquidsunloading}} = \left( \frac{P \times (V_{\text{vented}})}{\left( \frac{R}{MW_{\text{gas}}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{f}{907,185}$$

where:

$E_{\text{liquidsunloading}}$  = emissions from a single liquids unloading event [ton/event]

$P = 1$  [atm]

$V_{\text{vented}} = 5.9375$  [MSCF/event]

$R = 0.082$  [L-atm/mol-K]

$MW_{\text{gas}} = 17.3066$  [g gas/mole gas]

$T = 298$  [K]

$f = 0.03429$  [VOC fraction]

$3.5 \times 10^{-5}$  [MCF/L]

907,185 [g/ton]

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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Therefore:

$$E_{\text{liquidsunloading}} = \left( \frac{1 \times (5.9375)}{(0.082 / 17.3066) \times 298 \times 3.5 \times 10^{-5}} \right) \times \frac{0.03429}{907,185}$$

$$E_{\text{liquidsunloading}} = 0.004541 \text{ [ton/event]}$$

In this example, liquids unloading emissions are controlled through the use of a Plunger lift, ESP, or Beam Pump.

Therefore, total VOC emissions from liquids unloading venting in Cleburne County were calculated as follows:

$$E_{\text{liquidsunloading,TOTAL}} = E_{\text{liquidsunloading}} \times N_{\text{blowdown}} \times W_{\text{gas}} \times (1 - F_{\text{control,device}} \times C_{\text{efficiency}})$$

where:

$E_{\text{liquidsunloading,TOTAL}}$  are the total county-wide emissions of VOC from blowdowns [ton/yr]

$E_{\text{liquidsunloading}} = 0.004541$  [ton/event]

$N_{\text{blowdown}} = 64$  [event/yr-well]

$W_{\text{gas}} = 490$  [wells]

$F_{\text{control,device}} = 0.3769$  (fraction controlled)

$C_{\text{efficiency}} = 0.7063$  (control efficiency expressed as fraction)

Therefore:

$$E_{\text{liquidsunloading,TOTAL}} = 0.004541 \times 64 \times 490 \times (1 - 0.3769 \times 0.7063)$$

$$E_{\text{liquidsunloading,TOTAL}} = 104.5 \text{ [ton/yr]}$$

Note that if liquids unloading emissions were controlled through the use of flares, flaring emissions would be calculated using equations 40 and 41.

### **3.14 Loading**

This category refers to loading losses that occur when transferring hydrocarbon liquids, crude oil or condensate, from storage tanks to cargo trucks. Figure 3-13 shows truck loading operations at a tank battery in Mississippi.



**Figure 3-13. Truck Loading Operations**

The emissions from loading operations will vary by the gas speciation of the working losses; hence emissions were calculated separately for each hydrocarbon liquid. Equations 43-46 may be used for both categories (SCCs). The loading loss rate is estimated following Equation 43:

Equation 43) 
$$L = 12.46 \times \left( \frac{S \times V \times MW_{gas}}{T} \right)$$

where:

$L$  is the loading loss rate [lb/1,000gal]

$S$  is the saturation factor taken from AP-42 default values based on operating mode (here assumed as submerged loading: dedicated normal service)

$V$  is the true vapor pressure of the liquid loaded [psia]

$MW_{gas}$  is the molecular weight of the vapor [lb/lb-mole]

$T$  is the temperature of the bulk liquid [°R]

### Nonpoint Oil and Gas Emissions Estimation Tool

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VOC truck loading emissions are then estimated by Equation 44 which is dependent on the VOC fraction in the gas. When available, county-specific working/breathing gas compositions from condensate/crude oil storage tanks were used in Equations 44-46; however when county-level data was limited or unavailable, produced gas analyses were used to speciate emissions from each pollutant.

Equation 44) 
$$E_{loading, VOC} = \frac{L}{1,000} \times Y_{voc} \times \frac{42}{2,000}$$

where:

$E_{loading, VOC}$  are the VOC tank loading emissions [ton-VOC/bbl]

$L$  is the loading loss rate [lb/1,000gal]

$Y_{voc}$  is the weight fraction of VOC in the vapor in the liquid loaded

42 is a unit conversion [gal/bbl]

2,000 is a unit conversion [lbs/ton]

Emissions of other pollutants are calculated based on Equation 45:

Equation 45) 
$$E_{loading, i} = E_{loading, VOC} \times \frac{weight\ fraction_i}{weight\ fraction_{voc}}$$

where:

$E_{loading, i}$  is the total loading emissions of pollutant “i” per barrel of liquid [ton/bbl]

$(weight\ fraction_i / weight\ fraction_{voc})$  is the mass-based weight fraction of pollutant i divided by the weight fraction of VOC in the gas

### Extrapolation to county-level emissions

Annual emissions per pollutant i from condensate loading were scaled to county-level by annual condensate production per Equation 46:

Equation 46) 
$$E_{tank\ loadout, i} = E_{loading, i} \times P_{condensate} \times F_{trucked}$$

where:

$E_{tank\ loadout, i}$  is the annual county-level emissions for pollutant i from condensate tank load-out [ton/yr]

$E_{loading, i}$  is the emissions for pollutant i from loading per barrel [ton/bbl]

$P_{condensate}$  is the total annual of barrels condensate produced county-wide [bbl/yr]

$F_{trucked}$  is the fraction of condensate production that is delivered by truck

Annual emissions per pollutant i from oil loading were scaled to county-level by annual oil production per Equation 47:

Equation 47) 
$$E_{tank\ loadout, oil, i} = E_{loading, i} \times P_{oil} \times F_{trucked}$$



### **Nonpoint Oil and Gas Emissions Estimation Tool**

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where:

$E_{\text{tank loadout}, i}$  is the annual county-level emissions for pollutant  $i$  from crude oil tank load-out [ton/yr]

$E_{\text{loading}, i}$  is the emissions for pollutant  $i$  from loading per barrel [ton/bbl]

$P_{\text{oil}}$  is the total annual county-wide oil production [bbl/yr]

$F_{\text{trucked}}$  is the fraction of oil production that is delivered by truck

#### **Example Calculation for Loading:**

Using the equations provided above, VOC emissions for condensate loading in Columbia County, Arkansas were calculated as follows:

$$L = 12.46 \times \left( \frac{S \times V \times MW_{\text{gas}}}{T} \right)$$

where:

$L$  is the loading loss rate [lb/1,000gal]

$S = 0.6$  (based on submerged loading: dedicated normal service)

$V = 5.12$  [psia]

$MW_{\text{gas}} = 54.2$  [lb/lb-mole]

$T = 540$  [°R]

Therefore:

$$L = 12.46 \times \left( \frac{0.6 \times 5.12 \times 54.2}{540} \right)$$

$$L = 3.84 \text{ [lb/1,000gal]}$$

Total VOC emissions from all condensate loading in Columbia County can be evaluated as follows:

$$E_{\text{loading}, \text{VOC}} = \frac{L}{1,000} \times Y_{\text{voc}} \times \frac{42}{2,000}$$

where:

$E_{\text{loading}, \text{VOC}}$  are the VOC tank loading emissions [ton-VOC/bbl]

$L = 3.84$  [lb/1,000gal]

$Y_{\text{VOC}} = 0.933$

42 [gal/bbl]

2,000 [lb/ton]

Therefore:

$$E_{\text{loading}} = \frac{3.84}{1,000} \times 0.933 \times \frac{42}{2,000}$$



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$$E_{loading} = 0.0000752 \text{ [ton-VOC/bbl]}$$

Annual emissions of VOC from condensate loading are then scaled to the county-level using:

$$E_{tank \text{ loadout}} = E_{loading, VOC} \times P_{condensate} \times F_{trucked}$$

where:

$E_{tank \text{ loadout}}$  is the annual county-level emissions of VOC from condensate tank load-out [ton/yr]

$$E_{loading, VOC} = 0.0000752 \text{ [ton-VOC/bbl]}$$

$$P_{condensate} = 275,892 \text{ [bbl/yr]}$$

$$F_{trucked} = 1$$

Therefore:

$$E_{tank \text{ loadout}} = 0.0000752 \times 275,892 \times 1$$

$$E_{tank \text{ loadout}} = 20.76 \text{ [ton/yr]}$$

### **3.15 Mud Degassing**

Drilling mud degassing refers to the practice of extracting the entrained gas from the drilling mud once it is outside of the wellbore. During this process VOCs and CH<sub>4</sub> (and other pollutants in the gas) are vented to the atmosphere. National default emissions factors for mud degassing are available from The Climate Registry Reporting Protocol as shown in Table 3-4:

**Table 3-4. National Default Emissions Factors for Mud Degassing by Mud Base**

<b>Emission Source</b>	<b>Emission Factor Units<sup>5</sup></b>	<b>Emission Factor Units<sup>6</sup></b>
Mud degassing – water-based mud	881.84 lbs THC / drilling day	0.2605 tonnes CH <sub>4</sub> / drilling day
Mud degassing – oil-based mud	198.41 lbs THC / drilling day	0.0586 tonnes CH <sub>4</sub> / drilling day
Mud degassing – synthetic mud	198.41 lbs THC / drilling day	0.0586 tonnes CH <sub>4</sub> / drilling day

<sup>5</sup> Wilson, Darcy, Richard Billings, Regi Oommen, and Roger Chang, Eastern Research Group, Inc. Year 2005 Gulfwide Emission Inventory Study, U.S. Department of the Interior, Minerals Management Services, Gulf of Mexico OCS Region, New Orleans, December 2007, Section 5.2.10.

<sup>6</sup> Based on gas content of 65.13 weight percent CH<sub>4</sub>, derived from sample data provided in the original source of the emission factors. Original sample data is as follows, in terms of mole%: 83.85% CH<sub>4</sub>, 5.41% C<sub>2</sub>H<sub>6</sub>, 6.12% C<sub>3</sub>H<sub>8</sub>, 3.21% C<sub>4</sub>H<sub>10</sub>, and 1.40% C<sub>5</sub>H<sub>12</sub> (Wilson et al., 2007)

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Water-based mud emissions factors were assumed as a default conservative value, but this parameter may be updated in the tool. To account for the use of different mud bases within a region, the CH<sub>4</sub> emissions factor may be estimated as a weighted average based on a usage fraction of each mud type within a county.

Applying the local-gas CH<sub>4</sub> mass fraction to the mud degassing emission factors provides the site-representative emissions as shown in Equation 48. Because the mud entrained gas is the gas coming out directly from the wellbore during drilling, produced gas compositions by well type are used to characterize these emissions. Equations 48-49 are applicable to both oil and gas wells mud degassing emissions, however gas compositions and surrogate values (spuds) will vary for each well type.

Equation 48) 
$$E_{mudgas,CH_4} = N_{drill} \times EF_{mud,CH_4} \times 1.102 \times \frac{M_{CH_4}}{0.8385}$$

where:

$E_{mudgas,CH_4}$  is the mud degassing emissions for CH<sub>4</sub> per spud [ton/spud]  
 $N_{drill}$  is the number of drilling days per spud [drilling days/spud]  
 $EF_{mud,CH_4}$  is the emissions factor for CH<sub>4</sub> [tonne CH<sub>4</sub>/drilling days]  
0.8385 is the mole percent of CH<sub>4</sub> from the vented gas used to derive the emissions factor (EF)  
 $M_{CH_4}$  is the mole percent of CH<sub>4</sub> in the local gas vented during mud degassing [percent, expressed as a fraction] (if county-specific CH<sub>4</sub> emissions factor is used, M=0.8385)  
1.102 is the conversion of tonnes to short tons

To estimate emissions from other pollutants in the vented gas Equation 49 may be used:

Equation 49) 
$$E_{mudgas,i} = E_{mudgas,CH_4} \times \frac{MW_i}{MW_{CH_4}} \times \frac{M_i}{M_{CH_4}}$$

where:

$E_{mudgas,i}$  is the mud degassing emissions for pollutant i per spud [ton/spud]  
 $EF_{mudgas,CH_4}$  is the vented emissions for CH<sub>4</sub> [ton CH<sub>4</sub>/spud]  
 $MW_i$  is the molecular weight of pollutant i [lb/lb-mol]  
 $MW_{CH_4}$  is the molecular weight of CH<sub>4</sub> [lb/lb-mol]  
 $M_{CH_4}$  is the mole percent of CH<sub>4</sub> in the local gas vented during mud degassing [percent, expressed as a fraction]  
 $M_i$  is the mole percent of pollutant in the local gas vented during mud degassing [percent, expressed as a fraction]

### **Extrapolation to county-level emissions**

To estimate county-wide annual emissions, mud degassing emissions by spud are scaled with the county-wide count of drilling events (spuds), according to Equation 50:

### **Nonpoint Oil and Gas Emissions Estimation Tool**

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Equation 50) 
$$E_{mudgas, TOTAL\ i} = E_{mudgas, i} \times S_{spuds}$$

where:

$E_{mudgas, TOTAL, i}$  is the annual county-wide emissions for pollutant i from mud degassing [ton/yr]  
 $E_{mudgas, i}$  is the emissions from mud degassing from a drilling event [ton/spud]  
 $S_{spuds}$  is the number of wells drilled in a county for a particular year [spud/yr]

#### **Example Calculation for Mud Degassing:**

Using the equations provided above, VOC emissions for mud degassing in Cleburne County, Arkansas were calculated as follows:

$$E_{mudgas, CH_4} = N_{drill} \times EF_{mudgas, CH_4} \times 1.102 \times \frac{M_{CH_4}}{0.8385}$$

where:

$E_{mudgas, CH_4}$  is the mud degassing emissions for CH<sub>4</sub> per spud [ton/spud]  
 $N_{drill} = 20.22$  [drilling days/spud]  
 $EF_{mudgas, CH_4} = 0.2605$  [tonnes CH<sub>4</sub>/drilling days]  
 $M_{CH_4} = 0.94$  [percent, expressed as a fraction]  
 $0.8385$  = [mole fraction CH<sub>4</sub> used to derive emission factor]  
 $1.102$  [ton/tonnes]

Therefore:

$$E_{mudgas, CH_4} = 20.22 \times 0.2605 \times 1.102 \times \frac{0.94}{0.8385}$$

$$E_{mudgas, CH_4} = 6.51 \text{ [tons CH}_4\text{/well/yr]}$$

VOC emissions are then calculated using:

$$E_{mudgas, VOC} = E_{mudgas, CH_4} \times \frac{MW_{VOC}}{MW_{CH_4}} \times \frac{M_{VOC}}{M_{CH_4}}$$

where:

$E_{mudgas, VOC}$  is the emissions of VOC per completion [ton/completion]  
 $E_{mudgas, CH_4} = 6.51$  [ton CH<sub>4</sub>/well-yr]  
 $MW_{VOC} = 52.1$  [lb/lb-mol]  
 $MW_{CH_4} = 16.04$  [lb/lb-mol]  
 $M_{CH_4} = 0.94$  [percent CH<sub>4</sub>, expressed as a fraction]  
 $M_{VOC} = 0.01$  [percent VOC, expressed as a fraction]

### **Nonpoint Oil and Gas Emissions Estimation Tool**

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Therefore:

$$E_{mudgas,VOC} = 6.51 \times \frac{52.1}{16.04} \times \frac{0.01}{0.94}$$

$$E_{mudgas,VOC} = 0.225 \text{ [ton/well-yr]}$$

Total VOC emissions from all mud degassing in Cleburne County can be evaluated as follows:

$$E_{mudgas,TOTAL} = E_{mudgas,VOC} \times S_{spuds}$$

where:

$E_{mudgas,TOTAL}$  is the annual county-wide VOC emissions from mud degassing [ton/yr]

$E_{mudgas,VOC} = 0.225$  [ton/spud]

$S_{spuds} = 133$  [spud/yr]

Therefore:

$$E_{mudgas,TOTAL} = 0.225 \times 133$$

$$E_{mudgas,TOTAL} = 29.93 \text{ [ton/yr]}$$

### **3.16 Pneumatic Devices**

Pneumatic devices are located at the well site and use high-pressure produced gas to produce mechanical motion. These devices are typically under operation throughout the year and they may or may not vent the working fluid during operation, making them a potentially significant source of VOC emissions. Figure 3-14 shows a pneumatic device at a well in the Marcellus shale.<sup>1</sup>



**Figure 3-14. Pneumatic Device**

The counts of pneumatic devices vary between oil and gas wells, thus emissions are estimated separately for both well types. Emissions from pneumatic devices vary by the bleed rate of the device. Here it is assumed that four configurations can be found in a typical well: high bleed, low bleed, intermittent and no bleed. Emissions for the first three types of device  $i$  must be estimated. The methodology for estimating the emissions from pneumatic devices for a particular type of well are shown in Equation 51:

$$\text{Equation 51) } E_{pneumatic,j} = \frac{f_j}{907,185} \left( \sum_i \dot{V}_i \times N_i \times t_{annual} \right) \times \frac{P}{1,000 \times \left( \left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5} \right)}$$

where:

$E_{pneumatic,j}$  is the total emissions of pollutant  $j$  from all pneumatic devices for a particular type of well (oil vs. gas) [ton/yr/well]

$f_j$  is the mass fraction of pollutant  $j$  in the vented gas (produced gas)

$\dot{V}_i$  is the volumetric bleed rate from device  $i$  [SCF/hr/device]

$N_i$  is the number of devices  $i$  found in a type of well (oil vs. gas) [devices/well]

$t_{annual}$  is the number of hours per year that devices were operating [8760 hr/yr]

$P$  is the atmospheric pressure [1 atm]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of the gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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1,000 is the unit conversion factor SCF/MCF

### **Extrapolation to county-level emissions**

County-wide pneumatic device emissions for each well type are estimated according to Equation 52:

Equation 52) 
$$E_{pneumaticTOTAL,j} = E_{pneumatic,j} \times W_{gasoroil}$$

where:

$E_{pneumatic,TOTAL,j}$  is the total pneumatic device emissions of pollutant  $j$  in the county [ton/yr]

$E_{pneumatic,j}$  is the pneumatic device emissions of pollutant  $j$  for a type of well (gas vs. oil) [ton/yr/well]

$W_{gas\ or\ oil}$  is the total number of active gas (or oil) wells in the county [wells]

Total emissions from pneumatic devices will be the combination of county-wide emissions from each well type:

Equation 53) 
$$E_{allpneumatics,j} = [E_{pneumatic,TOTAL,j}]_{gaswells} + [E_{pneumatic,TOTAL,j}]_{oilwells}$$

Subpart W of the GHGRP prescribes bleed rates for low bleed, high bleed, and intermittent bleed devices that are to be used by reporters to estimate emissions. These rates, shown in Table 3-5 below, have been incorporated into the tool as default bleed rates for pneumatic devices used at oil and gas wells.

**Table 3-5. Whole Gas Bleed Rates for Pneumatic Devices**

<b>Onshore petroleum and natural gas production</b>	<b>Bleed Rate (scf/hour/component)</b>
Low Bleed Pneumatic Devices	1.39
High Bleed Pneumatic Devices	37.3
Intermittent Bleed Pneumatic Devices	13.5

The U.S. GHG Inventory utilizes per-well pneumatic device counts that are used in the tool. For gas wells, the total device counts in the U.S. GHG Inventory were used to derive default device counts by device type using the distribution between low, intermittent, and high bleed devices found in the CenSARA inventory and survey effort. The updated default device counts are shown in Table 3-6 below for each EIA Supply Region. (Note that for oil wells, the total device counts by device type will be updated in future inventories as EPA has identified a calculation error for the oil well device counts shown in Table 3-6.)

**Table 3-6. Pneumatic Device Counts for Oil and Gas Wells**

EIA Supply Region	Oil Well Device Counts			Gas Well Device Counts		
	Low Bleed	High Bleed	Intermittent Bleed	Low Bleed	High Bleed	Intermittent Bleed
North East	0.495	0.267	0	0.144	0.222	0.120
Midcontinent	0.495	0.267	0	0.460	0.709	0.382
Rocky Mountain	0.495	0.267	0	0.434	0.669	0.360
South West	0.495	0.267	0	0.394	0.607	0.327
West Coast	0.495	0.267	0	0.297	0.458	0.247
Gulf Coast	0.495	0.267	0	0.206	0.318	0.171

**Example Calculation for Pneumatic Devices:**

Using the equations provided above, VOC emissions from low-bleed pneumatic devices located at gas wells in Cleburne County, Arkansas were calculated as follows:

$$E_{pneumatic,VOC,well} = \frac{f}{907,185} \left( \sum_i \dot{V} \times N \times t_{annual} \right) \times \frac{P}{1,000 \times \left( \left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5} \right)}$$

where:

$E_{pneumatic,VOC,well}$  is the total emissions of VOC from low-bleed pneumatic devices  
[ton/yr/well]

$f = 0.0342$  [VOC fraction]

$\dot{V} = 3.151$  [SCF/hr/device]

$N = 0.99$  [devices/well]

$t_{annual} = 8,760$  [hr/yr]

$P = 1$  [atm]

$R = 0.082$  [L-atm/mol-K]

$MW_{gas} = 17.31$  [g/mol]

$T = 298$  [K]

$3.5 \times 10^{-5}$  [MCF/L]

907,185 [g/ton]

1,000 [SCF/MCF]

Therefore:

$$E_{pneumatic,VOC,well} = \frac{0.0342}{907,185} (3.151 \times 0.99 \times 8,760) \times \frac{1}{1,000 \times \left( \left( \frac{0.082}{17.31} \right) \times 298 \times 3.5 \times 10^{-5} \right)}$$

$$E_{pneumatic,VOC,well} = 0.021 \text{ [ton/yr/well]}$$

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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VOC emissions from low-bleed pneumatic devices located at gas wells in Cleburne County can be evaluated as follows:

$$E_{pneumaticVOC,TOTAL} = E_{pneumaticVOC,well} \times W_{gas}$$

where:

$E_{pneumatic,VOC,TOTAL}$  is the total pneumatic device emissions of VOC from low-bleed pneumatic devices located at gas wells in Cleburne county [ton/yr]

$E_{pneumatic,VOC,well} = 0.021$  [ton/yr/well]

$W_{gas} = 490$  [wells]

Therefore:

$$E_{pneumaticVOC} = 0.021 \times 490$$

$$E_{pneumatic,VOC} = 10.3 \text{ [ton/yr]}$$

### **3.17 Produced Water Tanks**

Water tank emissions are generated by working and breathing processes from tanks used to store produced water. Figure 3-15 shows produced water tanks in the Barnett Shale.



**Figure 3-15. Produced Water Tanks**



### **Nonpoint Oil and Gas Emissions Estimation Tool**

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Because information on oil and gas field handling of produced water is limited, emissions from this source were assumed uncontrolled. The methodology for estimating water tank emissions is shown below separately for gas wells and oil wells as water production and gas compositions for each well-type will differ:

#### **Gas well water tanks**

$$\text{Equation 54)} \quad E_{\text{water,gaswells,CH}_4} = \frac{EF_{\text{water,tanks,CH}_4}}{2,000} \times P_{\text{water,gas}} \times F_{\text{tank}}$$

where:

$E_{\text{water,gaswells,CH}_4}$  is the county-wide annual CH<sub>4</sub> emissions from water tanks located at gas wells [tons/yr]

$EF_{\text{water,tanks,CH}_4}$  is the emissions factor for CH<sub>4</sub> from working/breathing losses from water tanks in gas well sites [lb/bbl]

$P_{\text{water,gas}}$  is the county-wide annual water production [bbl/yr] from gas wells

$F_{\text{tank}}$  is the fraction of produced water directed to tanks [%]

2,000 is the unit conversion factor lbs/ton

#### **Oil well water tanks**

$$\text{Equation 55)} \quad E_{\text{water,oilwells,CH}_4} = \frac{(EF_{\text{water,LPwells,CH}_4} \times F + EF_{\text{water,RPwells,CH}_4} \times (1 - F))}{2,000} \times F_{\text{tank}} \times P_{\text{water,oil}}$$

where:

$E_{\text{water,oil wells,CH}_4}$  is the county-wide annual CH<sub>4</sub> emissions from water tanks located at oil wells [tons/yr]

$EF_{\text{water,LPwells,CH}_4}$  is the emissions factor for CH<sub>4</sub> from working/breathing losses from water tanks at low pressure oil wells (i.e. wells with artificial lifts) [lb/bbl]

$EF_{\text{water,RPwells,CH}_4}$  is the emissions factor for CH<sub>4</sub> from working/breathing losses from water tanks at regular pressure oil well sites [lb/bbl]

$F$  is the fraction of water production from oil wells with artificial lifts

$F_{\text{tank}}$  is the fraction of produced water directed to tanks [%]

$P_{\text{water,oil}}$  is the annual county-wide water production [bbl/yr] from oil wells

2,000 is the unit conversion factor lbs/ton

To estimate emissions of other pollutants in the losses from water tanks, the following equation may be used:

$$\text{Equation 56)} \quad E_{\text{water,wells},i} = EF_{\text{water,wells,CH}_4} \times \frac{MW_i}{MW_{\text{CH}_4}} \times \frac{M_i}{M_{\text{CH}_4}}$$

## Nonpoint Oil and Gas Emissions Estimation Tool

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where:

$E_{water,wells,i}$  is the water tank county-wide venting losses of pollutant  $i$  from water tanks at particular well type (oil or gas) [ton/yr]

$EF_{water,wells,CH_4}$  is the water tank emissions for  $CH_4$  for a particular well type [ton  $CH_4$ /yr]

$MW_i$  is the molecular weight of pollutant  $i$  [lb/lb-mol]

$MW_{CH_4}$  is the molecular weight of  $CH_4$  [lb/lb-mol]

$M_{CH_4}$  is the mole percent of  $CH_4$  in the water tanks gas (local produced gas) [%]

$M_i$  is the mole percent of pollutant in the water tanks gas (local produced gas) [%]

### Extrapolation to county-level emissions

County-wide emissions from produced water tanks are estimated directly from equations 55 through 57. The sum of oil wells and gas wells water tank emissions yield total county-wide emissions from water tanks.

### Example Calculation for Produced Water Tanks:

Using the equations provided above, VOC emissions for produced water tanks in Columbia County, Arkansas were calculated as follows:

Venting emissions ( $CH_4$ ) from gas wells:

$$E_{water,gaswell} = \frac{EF_{water,tank}}{2,000} \times P_{water,gas} \times F_{tank}$$

where:

$E_{water,gaswell}$  is the county-wide annual  $CH_4$  emissions from water tanks located at gas wells [ton/yr]

$EF_{water,tank} = 0.11$  [lb  $CH_4$ /bbl]

$P_{water,gas} = 1,234,207$  [bbl/yr]

$F_{tank} = 1$  [%]

2,000 [lb/ton]

Therefore:

$$E_{water,gaswell} = \frac{0.11}{2,000} \times 1,234,207 \times 1$$

$$E_{water,gaswell} = 67.9 \text{ [tons } CH_4/\text{yr]}$$

VOC emissions are then calculated using:

$$E_{water,gaswell,VOC} = E_{water,gaswell} \times \frac{MW_{VOC}}{MW_{CH_4}} \times \frac{M_{VOC}}{M_{CH_4}}$$

## **Nonpoint Oil and Gas Emissions Estimation Tool**

where:

$E_{water,gaswell,VOC}$  is the emissions of VOC from produced water at gas wells [ton/yr]

$EF_{water,gaswell} = 67.9$  [tons CH<sub>4</sub>/yr]

$MW_{VOC} = 59.5$  [lb/lb-mol]

$MW_{CH_4} = 16.04$  [lb/lb-mol]

$M_{CH_4} = 0.89$  [percent CH<sub>4</sub>, expressed as a fraction]

$M_{VOC} = 0.04$  [percent VOC, expressed as a fraction]

Therefore:

$$E_{water,gaswell,VOC} = 67.9 \times \frac{59.5}{16.04} \times \frac{0.04}{0.89}$$

$$E_{water,gaswell,VOC} = 11.32 \text{ [ton/yr]}$$

### **3.18 Well Completions**

This category refers to emissions from well completions events, which includes initial completions and recompletions. Data provided in the Enverus database includes a count of annual well completions (combines initial and recompletions), thus county-wide emissions will be a combination of the two. However, well completions characteristics will vary by well type; hence emissions are estimated separately for gas well completions and oil well completions. Additionally, emissions are estimated separately for unconventional and conventional completions.

Figure 3-16 shows temporary storage tanks used to collect flowback fluids at an unconventional well completion in the Barnett Shale. Emissions are generated as gas entrained in the flowback fluid is emitted through open vents at the top of the tanks.



**Figure 3-16. Well Completion**

### Nonpoint Oil and Gas Emissions Estimation Tool

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The calculation methodology for estimating emissions from a single, uncontrolled completion event is shown below in Equation 57. Emissions from well completions controlled by flaring or use of green completions are the calculated using equations 58 - 60 as described below.

$$\text{Equation 57)} \quad E_{\text{completion},i} = \left( \frac{P \times (Q_{\text{completion}})}{\left( \frac{R}{MW_{\text{gas}}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{f_i}{907,185}$$

where:

$E_{\text{completion},i}$  is the uncontrolled emissions of pollutant  $i$  from a single completion event [ton/event]

$P$  is atmospheric pressure [1 atm]

$Q_{\text{completion}}$  is the uncontrolled volume of gas generated per completion [MCF/event]

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{\text{gas}}$  is the molecular weight of the gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$f_i$  is the mass fraction of pollutant  $i$  in the completion venting gas

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

### Flaring emissions from well completion controls

The methodology for estimating flaring emissions from completion venting processes is described below:

$$\text{Equation 58)} \quad E_{\text{flare,completion}} = \left( \frac{EF_i \times Q_{\text{completion}} \times F \times (C_{\text{captured}}) \times (C_{\text{efficiency}}) \times HV}{1,000} \times WC_{\text{county}} \right) / 2,000$$

where:

$E_{\text{flare,completion}}$  is the county-wide flaring emissions of pollutant  $i$  for well completions [ton/yr]

$EF_i$  is the flaring emissions factor for pollutant  $i$  [lb/MMBtu]

$Q_{\text{completion}}$  is the uncontrolled volume of gas generated per completion [MCF/event]

$F$  is the fraction of well completions with flares

$C_{\text{captured}}$  is the capture efficiency of the flare

$C_{\text{efficiency}}$  is the control efficiency of the flare

$HV$  is the local heating value of the gas [BTU/SCF]

$WC_{\text{county}}$  is the county-wide number of well completion events for a particular year [events/yr]

2,000 is the unit conversion factor lbs/ton

1,000 is the unit conversion factor MCF/MMCF

### Nonpoint Oil and Gas Emissions Estimation Tool

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The methodology for estimating SO<sub>2</sub> emissions from flaring of completion vent gas is shown below:

Equation 59)

$$E_{flare, completion, SO_2} = \left( \frac{P \times (Q_{completion} \times WC_{county}) \times F \times (C_{captured}) \times (C_{efficiency})}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times f_{H_2S} \times \frac{2}{907,185}$$

where:

$E_{flare, completion, SO_2}$  is the county-wide SO<sub>2</sub> flaring emissions from flaring of completion vent gas [ton/yr]

$P$  is atmospheric pressure [1 atm]

$Q_{completion}$  is the uncontrolled volume of gas generated per completion [MCF/event]

$WC_{county}$  is the county-wide number of well completion events for a particular year [events/yr]

$F$  is the fraction of well completions with flares

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

$R$  is the universal gas constant [0.082 L-atm/mol-K]

$MW_{gas}$  is the molecular weight of the completion venting gas [g/mol]

$T$  is the atmospheric temperature [298 K]

$f_{H_2S}$  is the mass fraction of H<sub>2</sub>S in the completion venting gas

$3.5 \times 10^{-5}$  is the unit conversion factor MCF/L

907,185 is the unit conversion factor g/ton

### Extrapolation to county-level emissions

Controlled, county-wide emissions are obtained by scaling-up well completions by well type using the number of completion events by well type by year and accounting for any controls used. This is done by applying Equation 60:

Equation 60)

$$E_{completionTOTAL} = E_{completioni} \times WC_{county} (1 - F_{flare} \times (C_{captured}) \times (C_{efficiency}) - F_{green}) + E_{flare, completioni}$$

where:

$E_{completion, TOTAL}$  are the total emissions county-wide of pollutant i from well completions [tons/yr]

$E_{completion, i}$  are the completion emissions from a single completion event [tons/event]

$WC_{county}$  is the county-wide total completions events in a particular year [events/yr]

$F_{flare}$  is the fraction of completions in the county controlled by flare

$C_{captured}$  is the capture efficiency of the flare

$C_{efficiency}$  is the control efficiency of the flare

### Nonpoint Oil and Gas Emissions Estimation Tool

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$F_{green}$  is the fraction of completions in the county that were controlled by green completion techniques

$E_{flare, completion, i}$  is the county-wide flaring emissions from flaring of completion vent gas [ton/yr]

#### Example Calculation for Well Completions:

Using the equations provided above, VOC emissions from venting of controlled (accounting for both flaring and green completions) oil well completions in Columbia County, Arkansas were calculated as follows:

$$E_{completion} = \left( \frac{P \times (Q_{completion})}{\left( \frac{R}{MW_{gas}} \right) \times T \times 3.5 \times 10^{-5}} \right) \times \frac{f}{907,185}$$

where:

$E_{completion}$  is the uncontrolled emissions of VOC from a single completion event [ton/event]

$P = 1$  [atm]

$Q_{completion} = 226$  [MCF/event]

$R = 0.082$  [L-atm/mol-K]

$MW_{gas} = 24.25$  [g/mol]

$T = 298$  [K]

$f = 0.26$  [VOC fraction]

$3.5 \times 10^{-5}$  [MCF/L]

$907,185$  [g/ton]

Therefore:

$$E_{completion} = \left( \frac{1 \times (226)}{\left( \frac{0.082}{24.25} \right) \times 298 \times 3.5 \times 10^{-5}} \right) \times \frac{0.26}{907,185}$$

$$E_{completion} = 1.84 \text{ [ton/event]}$$

Well completion flaring emissions are calculated similarly to the example given above for condensate tanks. In this case,  $E_{flare, completion, VOC} = 0.552$  [ton/yr]

Total VOC emissions from well completion venting and flaring in Columbia County were calculated as follows:

$$E_{completionTOTAL} = E_{completion} \times WC_{county} \left( (1 - F_{flare} \times (C_{captured}) \times (C_{efficiency}) - F_{green}) + E_{flare, completion} \right)$$

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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where:

$E_{completion,TOTAL}$  are the total emissions county-wide of VOC from well completions [tons/yr]

$E_{completion} = 1.84$  [tons/event]

$WC_{county} = 62$  [events/yr]

$F_{flare} = 0.833$  (fraction flared)

$C_{captured} = 0.898$  (capture efficiency expressed as fraction)

$C_{efficiency} = 0.98$  (control efficiency expressed as fraction)

$F_{green} = 0.167$  (fraction green completions)

$E_{flare,completion} = 0.552$  [ton/yr]

Therefore:

$$E_{completion,TOTAL} = 1.84 \times 62 (1 - 0.833 \times (0.898) \times (0.98) - 0.167) + 0.552$$

$$E_{completion,TOTAL} = 11.95 \text{ [ton/yr]}$$

### **3.19 Wellhead Compressor Engines**

Wellhead compressor engines are generally small natural gas-fired engines located at the well site and used to boost produced gas pressure from downhole pressure to the required pressure for delivery to a transmissions pipeline. Compressor engines may also be used to assist in removal of accumulated liquids in the wellbore (artificial lift), or as vapor recovery units to collect vapors from various equipment on the wellpad for routing to a control device or sales line. The fractional usage of these engines will depend on the basin characteristics; hence for those basins that largely require wellhead compression, this may be a significant nonpoint source of NO<sub>x</sub> emissions. Figure 3-17 shows two wellhead compressor engines in the Barnett shale.



**Figure 3-17. Wellhead Compressor Engines**

Compressor engines found at a wellhead were categorized into two main categories in this analysis and thus emissions are estimated for each type of engine and consequently extrapolated to county-wide emissions. These categories of compressors are:

- Rich burn compressors
- Lean burn compressors

The basic methodology for estimating emissions from wellhead compressor engines is shown in Equation 61:

$$\text{Equation 61)} \quad E_{engine, type} = \frac{EF_i \times HP \times LF \times t_{annual}}{907,185} \times (1 - F_{controlled} \times CF_i)$$

where:

$E_{engine, type}$  are emissions from a particular type (rich vs. lean) of compressor engine [ton/yr/engine]

$EF_i$  is the emissions factor of pollutant  $i$  [g/hp-hr] (note that this may be different for NO<sub>x</sub> emissions from rich-burn vs. lean-burn engines)

$HP$  is the horsepower of the engine [hp]

$LF$  is the load factor of the engine

$t_{annual}$  is the annual number of hours the engine is used [hr/yr]

$F_{controlled}$  is the fraction of compressors of a particular type (rich vs. lean) that are controlled

$CF_i$  is the control factor for controlled engines for pollutant  $i$

907,185 is the unit conversion factor g/ton

**Extrapolation to county-level emissions**

County-level emissions are made up of the combination of emissions from each type of wellhead compressor, rich burn and lean burn. Emissions are scaled to county level using the usage fraction ( $F$ ) of each engine type against all other compressor engines, the fraction of wells with wellhead compressor engines, and the total gas well count in a county, according to equation below:

$$\text{Equation 62)} \quad E_{engine, TOTAL} = (F_{rich} E_{engine, rich} + F_{lean} E_{engine, lean}) \times W_{gas} \times f_{wellhead}$$

where:

$E_{engine, TOTAL}$  is the total emissions from wellhead compressor engines in a county [ton/yr]

$F_{rich}$  is the fraction of rich-burn wellhead compressors in the county amongst all wellhead compressors

$E_{engine, rich}$  is the total emissions from a single rich burn compressor engine per Equation (61) [ton/yr]



### **Nonpoint Oil and Gas Emissions Estimation Tool**

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$F_{lean}$  is the fraction of lean-burn wellhead compressors in the county amongst all wellhead compressors

$E_{engine,lean}$  is the total emissions from a single lean burn compressor engine per Equation (61) [ton/yr]

$W_{gas}$  is the total gas well count in a county

$f_{wellhead}$  is the fraction of all gas wells in the county with wellhead compressor engines

#### **Example Calculation for Rich-Burn Wellhead Compressor:**

Using the equations provided above, NO<sub>x</sub> emissions from rich-burn wellhead compressor engines in Cleburne County, Arkansas were calculated as follows:

$$E_{engine,rich} = \frac{EF \times HP \times LF \times t_{annual}}{907,185} \times (1 - F_{controlled} \times CF)$$

where:

$E_{engine,rich}$  = emissions from a rich-burn wellhead compressor engine [ton/yr/engine]

$EF = 8.24$  [g/hp-hr]

$HP = 105.5$  [hp]

$LF = 0.77$  (load factor for the engine)

$t_{annual} = 8,370$  [hr/yr]

$F_{controlled} = 0.44$  (fraction of engines controlled)

$CF = 0.90$  (control factor)

907,185 [g/ton]

Therefore:

$$E_{engine,rich} = \frac{8.24 \times 105.5 \times 0.77 \times 8,370}{907,185} \times (1 - 0.44 \times 0.90)$$

$$E_{engine,rich} = 3.73 \text{ [ton/yr/engine]}$$

Total NO<sub>x</sub> emissions from all rich-burn wellhead compressor engines in Cleburne County can be evaluated as follows:

$$E_{engine,rich,TOTAL} = (F_{rich} \times E_{engine,rich}) \times W_{gas} \times f_{wellhead}$$

where:

$E_{engine,rich,TOTAL}$  = total emissions from rich-burn compressor engines in a county [ton/yr]

$F_{rich} = 0.490$  (fraction of rich burn engines)

$E_{engine,rich} = 3.73$  [ton/yr/engine]

$W_{gas} = 490$  [wells]

$f_{wellhead} = 0.0845$  (fraction of gas wells with compressor engines)

Therefore:

$$E_{engine,rich,TOTAL} = (0.490 \times 3.73) \times 490 \times 0.0845$$

***Nonpoint Oil and Gas Emissions Estimation Tool***

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$$E_{engine, rich, TOTAL} = 75.7 \text{ [tons/NO}_x\text{/yr]}$$

**4.0 TOOL NONPOINT OIL AND GAS EMISSIONS SUMMARY**

Table 4-1 presents a summary of nonpoint oil and gas emissions generated by the tool by state for 2020.

**Table 4-1. State-wide Tool Emissions Estimates**

State	NO <sub>x</sub> (TPY)	VOCs (TPY)	CO (TPY)	Total HAP (TPY)
Alabama	3,983	9,749	5,612	380
Alaska	2,163	9,636	3,583	491
Arizona	8	20	12	1
Arkansas	4,179	7,606	3,844	343
California	512	23,639	670	1,028
Colorado	24,812	65,367	32,456	5,885
Florida	14	493	24	14
Idaho	2	6	3	<1
Illinois	13,343	52,974	20,147	339
Indiana	2,610	11,858	3,659	80
Kansas	22,029	53,235	32,267	1,230
Kentucky	12,071	35,820	17,725	796
Louisiana	19,003	56,920	26,183	6,481
Maryland	<1	1	1	<1
Michigan	8,993	10,528	12,673	524
Mississippi	1,650	6,478	2,333	147
Missouri	370	810	567	8
Montana	1,762	26,467	2,617	1,385
Nebraska	284	1,780	417	12
Nevada	1	117	2	1
New Mexico	189,694	220,327	277,405	7,343
New York	733	5,634	1,036	110
North Dakota	30,285	230,906	36,094	9,631
Ohio	1,572	17,085	1,691	378
Oklahoma	32,570	137,216	35,001	5,470
Oregon	10	17	14	1
Pennsylvania	34,353	121,985	48,715	25,138
South Dakota	142	1,039	237	40
Tennessee	773	2,180	1,150	40
Texas	146,821	859,862	188,589	25,669
Utah	6,974	46,825	10,695	1,580
Virginia	3,498	8,684	4,998	502
West Virginia	18,855	79,692	26,833	9,720
Wyoming	16,243	81,574	24,284	3,707

**Table 4-1. State-wide Tool Emissions Estimates**

State	NO <sub>x</sub> (TPY)	VOCs (TPY)	CO (TPY)	Total HAP (TPY)
<b>Total</b>	<b>600,310</b>	<b>2,186,532</b>	<b>821,535</b>	<b>108,476</b>

While there is some variability in emissions due to regional and basin-specific factors such as the VOC weight percent in natural gas, in general, the relative magnitude of state-wide emissions is dependent on the level of oil and gas activity in each state. As shown in Table 4-1, the highest emissions occur in those states with the highest oil and gas production.

Table 4-2 presents a summary of national emissions for 2020 for each source category as calculated by the tool.

**Table 4-2. Source Category Tool Emissions Estimates**

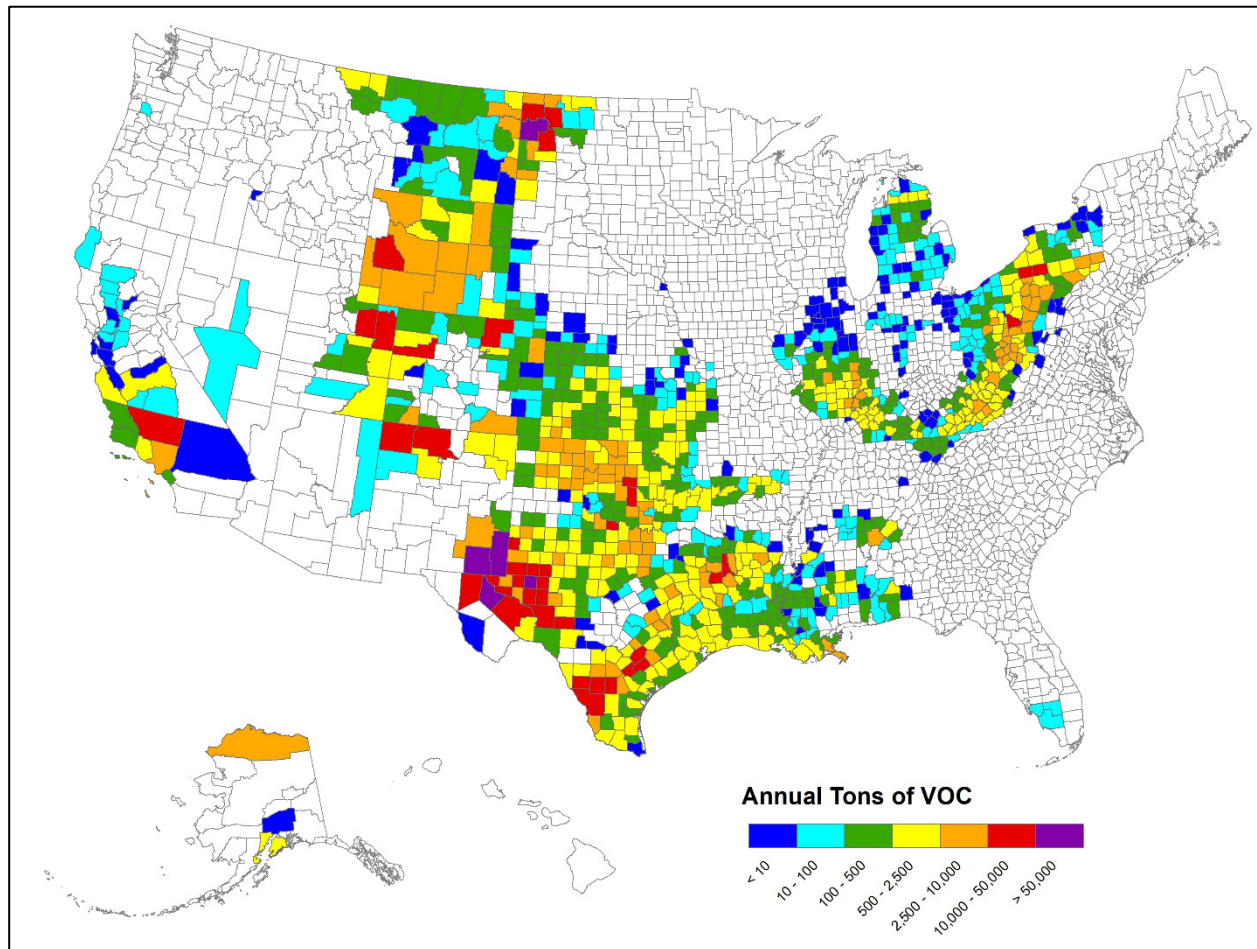
Source Category	NO <sub>x</sub> (TPY)	VOCs (TPY)	CO (TPY)	Total HAP (TPY)
Artificial Lifts	253,498	3,306	391,972	3,621
Associated Gas	682	108,782	3,606	2,003
CBM Dewatering Pump Engines	<1	<1	<1	<1
Condensate Tanks	204	48,204	1,078	925
Crude Oil Tanks	3,712	744,528	19,621	19,900
Dehydrators	495	102,084	1,311	65,530
Drill Rigs	40,043	1,672	6,124	864
Fugitives	<1	231,224	<1	1,214
Gas-Actuated Pumps	<1	146,080	<1	1,137
Heaters	28,800	2,722	41,567	948
Hydraulic Fracturing	20,570	823	2,779	442
Lateral/Gathering Compressor Engines	108,563	3,220	153,624	2,670
Liquids Unloading	87	81,055	461	400
Loading Emissions	<1	18,662	<1	674
Mud Degassing	<1	24,396	<1	91
Pneumatic Devices	<1	534,334	<1	3,088
Produced Water	<1	87,640	<1	269
Well Completions	434	42,923	2,293	772
Wellhead Compressor Engines	143,222	4,880	197,098	3,928
<b>Total</b>	<b>600,310</b>	<b>2,186,532</b>	<b>821,535</b>	<b>108,476</b>

As Table 4-2 illustrates, NO<sub>x</sub> emissions are largely dominated by artificial lift engines and wellhead compressor emissions. This is particularly true for states with a large number of active oil and gas wells. Other significant sources of NO<sub>x</sub> include lateral compressors, well-site heaters, and drilling and hydraulic fracturing engines. Pneumatic devices and crude oil storage

### **Nonpoint Oil and Gas Emissions Estimation Tool**

tanks are the most significant source of VOC emissions in many states. Other key sources of VOC emission include associated gas venting and fugitives (equipment leaks).

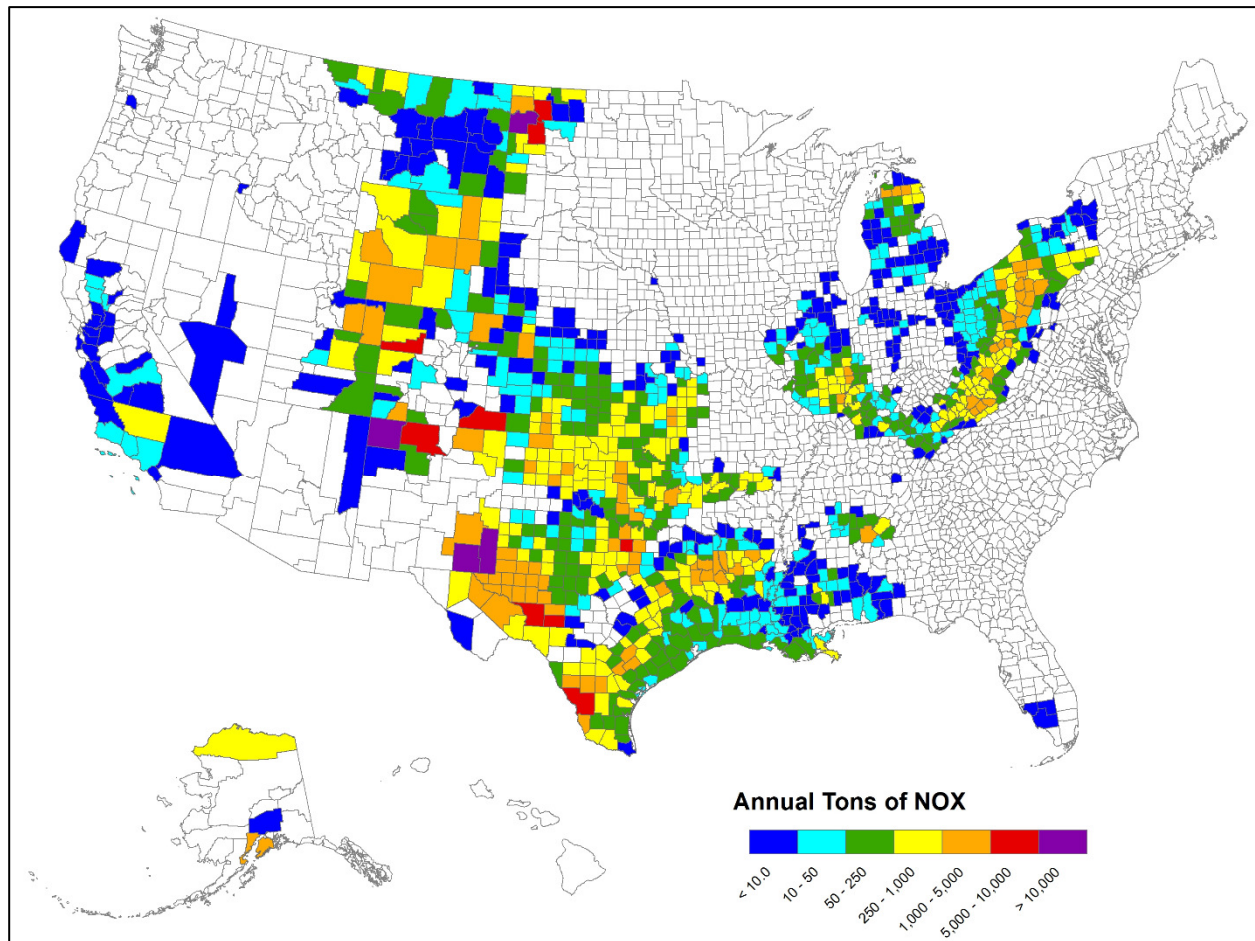
Figure 4-1 below shows 2020 tool nonpoint oil and gas VOC emissions for each county.



**Figure 4-1. Tool Nonpoint Oil and Gas VOC Emissions**

### **Nonpoint Oil and Gas Emissions Estimation Tool**

Figure 4-2 below shows 2020 tool nonpoint oil and gas NO<sub>x</sub> emissions for each county.



**Figure 4-2. Tool Nonpoint Oil and Gas NO<sub>x</sub> Emissions**

## **5.0 NEI NONPOINT OIL AND GAS EMISSIONS SUMMARY**

To develop emissions estimates for the nonpoint oil and gas sector in the 2020 NEI, some states relied on the tool described in detail in this report. While there is much overlap between the NEI and the tool, it is worth emphasizing again that *the tool is not the oil and gas sector NEI*. For many states, the nonpoint oil and gas sector data submitted for inclusion in the NEI are exactly the same (or very close to the same) as the data generated by the tool. This is true for states like Oklahoma that participated in the CenSARA study and which provided corrections and additional input during the development of the tool and which used the tool to generate the data that were submitted to the NEI. This is also the case for states like North Dakota that accepted the NEI emissions data for this sector that were generated by EPA using the tool. In other cases, (e.g., Texas), states have collected data from oil and gas operators directly and have supplemented that data with data from the tool as needed. And still other states (e.g., Pennsylvania) have used the tool in an iterative fashion, generating separate sets of emissions using specific emission factors, activity values, and input parameters selected to reflect a variety of source categories (e.g., coal-bed methane wells, conventional gas wells, unconventional wells) and summed the results (on a county-by-county basis) to yield a more accurate representation of emissions from this sector in their states. In short, the tool has been used to inform the NEI, but the parameters incorporated into the tool (and the emissions generated by the tool) may or may not be the same as the data incorporated into the NEI.

## **6.0 RECOMMENDED IMPROVEMENT ACTIVITIES FOR FUTURE NONPOINT OIL AND GAS EMISSION INVENTORIES**

The nonpoint oil and gas emissions estimation tool developed under this effort provides EPA with default emission estimates for each oil and gas producing county in the country. As mentioned above, these estimates have been used by EPA to gapfill the NEI when state-supplied data is unavailable. Currently, emission estimates in the tool are based on process characterization data and emission factors developed by CenSARA, EPA, the WRAP, and numerous state and local air quality agencies. As available, the data included in the tool is resolved spatially down to the county level to provide a greater geographic specificity. For some areas of the country, region specific information was not available and the tool has been populated for these areas using default data from the CenSARA inventory or from EPA. It is expected that these areas have their own unique characteristics that are not reflected in the data currently used in the tool.

Many states, intergovernmental agencies, and other groups have developed their own oil and gas nonpoint emission inventories using localized data such as air permitting records and drilling permits and authorizations and have submitted these inventories to EPA for inclusion in the NEI. Additionally, EPA anticipates that substantial amounts of new information on the oil and gas sector will become available in the coming years from a variety of ongoing studies being conducted by government, academic, and industry researchers and organizations. For example, the required reporting of GHG emissions and other data by the oil and gas sector under Subpart W of GHGRP continues to expand, and the recent changes to the New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP) applicable to this industry have required much more detailed monitoring and recordkeeping than this industry was subject to even three or four years ago. As such, EPA continues to review information and data from these sources as they become available for potential incorporation into the tool.

Given the above, the following recommended improvements are presented for consideration for future development and refinement of the tool:

- **Continued coordination between EPA, states, and intergovernmental agencies to exchange and share information from their oil and gas nonpoint source inventory programs.** Many states have compiled nonpoint emission estimates and methodologies for oil and gas sources. For example, TCEQ's oil and gas inventory served as the starting point for development of the CenSARA inventory, which was then developed further into the tool; Pennsylvania has developed a specific emissions inventory for unconventional exploration and production; and Wyoming inventories individual oil and gas well pads. A free and open exchange of data, including mechanisms to make such data sharing easy for all users, would be beneficial to all parties. This is especially important for states that have relied on their own data with or without supplementing that data with data from the tool. In addition, it would be helpful to compare inventories compiled by states to what is generated by the tool, especially in cases where the state estimates and the tool estimates differ



## **Nonpoint Oil and Gas Emissions Estimation Tool**

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dramatically. This comparison would help facilitate much-needed quality control analysis. This is especially important where emission methodologies differ as, for example, where states rely on individual company submissions for each individual wellhead site and the tool relies on county-level activity factors and process characterization data. The National Oil & Gas Emissions Committee has created an information repository to facilitate such information transfer (<http://vibe.cira.colostate.edu/OGEC/>).

- **Conduct data collection surveys in areas not under the CenSARA domain.** In addition to reaching out to interested states and intergovernmental agencies that are currently collecting data or estimating emissions from nonpoint oil and gas sources, additional surveys should be conducted to obtain basin-specific process characterization data for areas of the country that are not currently well characterized in the tool.
- **Add processes, control devices, and source categories.** Additional processes such as saltwater injection, vapor recovery unit engines, turbines, flares (as a separate source type), construction and workover equipment, and other source categories could be added to the tool as suggested by stakeholders.
- **Update emission estimation methodologies to account for electric-powered equipment.** Many wellhead sites, especially those in urban areas with access to electrical power, are being hooked up to the grid to power equipment currently powered by field gas. Including options in the tool to identify the fraction of units powered by electricity would help refine the emission estimates for affected categories.
- **Allow for various levels of granularity.** Consider adding the ability to perform more granular estimates at the sub-basin, field, or formation level or for well type (e.g. conventional and unconventional) or age for states that have those data available, while allowing for a less granular approach where detailed sub-basin data are lacking.
- **Improve the tool reports capability.** The tool could be modified to facilitate generation of additional reports requested by stakeholders, which would aid in data analysis and quality assurance operations.
- **Consider adding a module to evaluate midstream oil and gas emissions.** A number of states collect point-source emissions data from midstream oil and gas companies and submit that data to the NEI. For states that do not collect point-source midstream data, it would be helpful to include nonpoint emissions module for this sector. In addition, the demarcation between the midstream and upstream sectors could be made clearer to determine exactly what the tool currently covers, and what it does not. Alternatively, an entirely separate midstream tool could be developed.

**APPENDIX A – INSTRUCTIONS FOR USING THE EPA NONPOINT OIL AND GAS EMISSIONS  
ESTIMATION TOOL, EXPLORATION MODULE (12/2/2021)**

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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### **Instructions for Using the 2020 EPA Nonpoint Oil and Gas Emissions Estimation Tool, Exploration Module (12/2/2021)**

#### **1.0 Introduction**

Under Work Assignment with U.S. EPA, Eastern Research Group, Inc. (ERG) was tasked to develop a tool that state, local, and tribal (SLT) agencies could use to develop a nonpoint source emission inventory for upstream oil and natural gas activities. To this end, ERG prepared the EPA Nonpoint Oil and Gas Emissions Estimation Tool for the 2011 base year to assist agencies in compiling, allocating, and adjusting upstream oil and natural gas activity data, and developing county-level nonpoint source emission estimates.

In support of the 2014 NEI, U.S. EPA directed ERG to redesign the Tool to enhance the User experience. Such enhancements included, but were not limited to: 1) the development of a “Dashboard View” to guide the User; 2) the creation of data entry forms; 3) the creation of a MS Excel-based data import/export utility; 4) ability to view EPA default data; and 5) more flexibility in how data are presented. As part of this work and to increase the efficiency, the Tool was split into two separate modules (i.e., two separate databases): exploration activities and production activities. These instructions address use of the exploration module.

For the 2017 NEI, U.S. EPA directed ERG to build upon the re-engineered Production and Exploration Tools to reflect 2017 activity, as well as include additional PM species, update county FIPS code changes, and include new source categories and pollutants, when available.

For the 2020 NEI, EPA included basin-level speciation and non-speciation factor updates. The tool generated estimates for 57 source classification codes (SCCs) and 70 pollutants. Where state or local data were not submitted to the NEI, EPA uses the estimates generated for inclusion in the 2020 NEI.

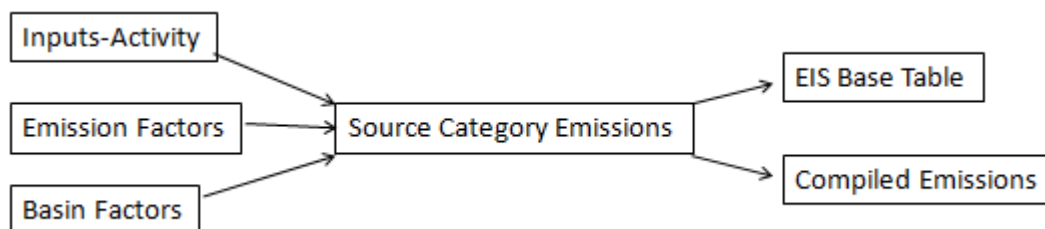
#### **2.0 MS-Access Databases**

The Nonpoint Oil and Gas Emissions Estimation Tools were programmed in MS-Access. This platform offered several advantages, particularly in accessibility (software is available to most users), familiarity (MS-Access is used by most SLT agencies in preparation of Emission Inventory System (EIS) data files), and portability (the tool modules can be e-mailed as zipped files that are less than 25 MB each in size).

Included with the tool are the “area\_bridgetool” blank staging tables which are to be used for preparation of EIS data files.

#### **3.0 Tool Data Flow**

The basic concept of the tool is to calculate the source category emissions using the activity data, emission factors, and basin factors. A conceptual flow is:



#### **4.0 Steps for Using the Oil and Natural Gas Tool for Exploration Sources to Generate Emissions**

In this section, steps will be outlined to generate emissions from the Exploration sources.

## **Nonpoint Oil and Gas Emissions Estimation Tool**

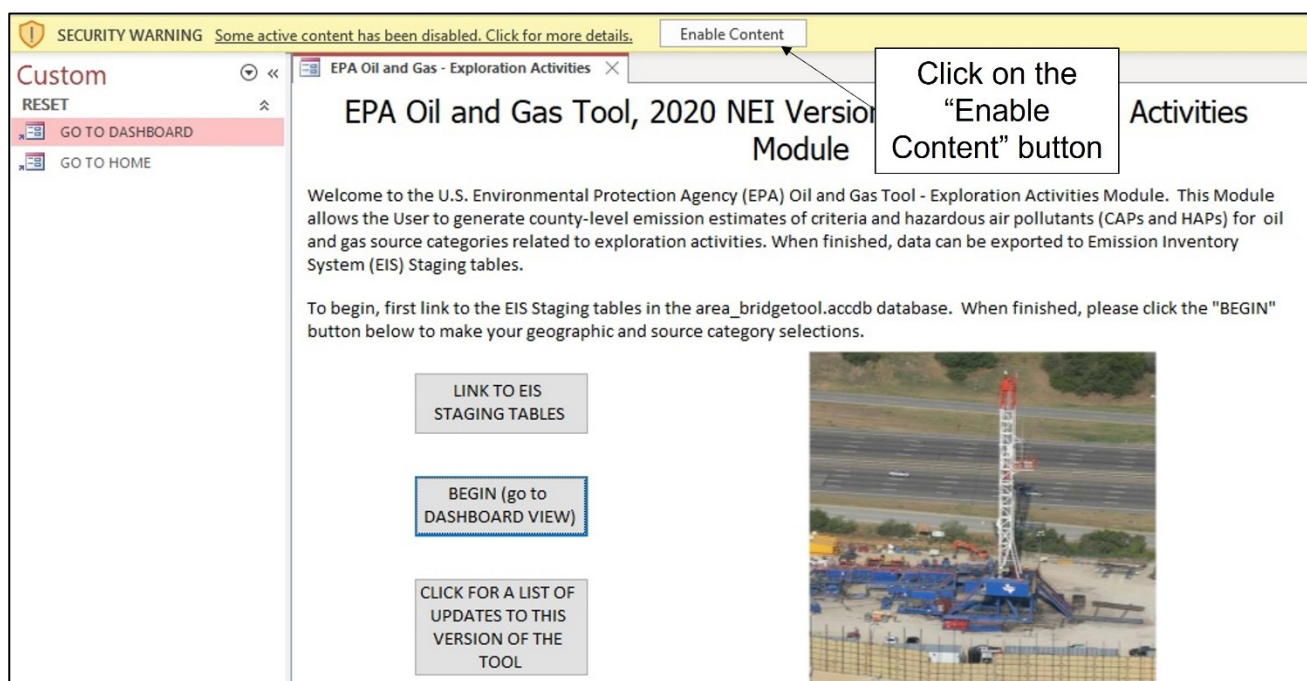
Note: If the User will be editing an existing version of the database and wishes to reset the tool and regenerate the emissions, the following steps are recommended:

- a. Click on the “Reset All Selections/Go to Step 1” button at the top of the Dashboard; and
- b. Compact and Repair the database.

### **4.1 Preparation**

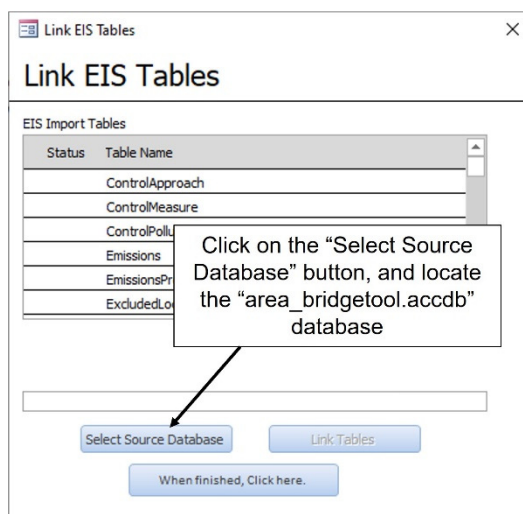
Prior to running the tool, the User must properly link the data tables in the Nonpoint Emissions Staging Tables within the tool. To do this, follow the instructions below:

- 1) Place both the “OIL\_GAS\_TOOL\_2020\_NEI\_EXPLORATION\_V1\_1.accdb” and the “area\_bridgetool.accdb” database tables in the same directory. It is recommended that the User creates an “EPA\_OIL\_GAS\_2020” directory on their hard drive.
- 2) Open the “OIL\_GAS\_TOOL\_2020\_NEI\_EXPLORATION\_V1\_1.accdb” database. You will need to “Enable Content” if the message pops up.

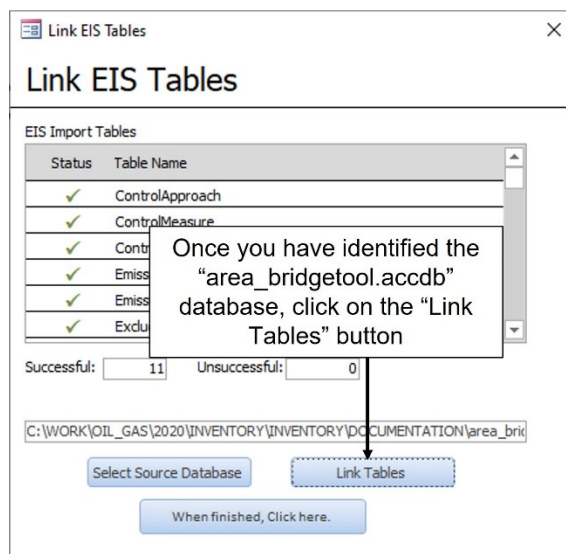


- 3) Click on the “LINK TO EIS STAGING TABLES” button, and a pop-up box will appear. Follow the instructions to link in the EIS Staging tables in the “area\_bridgetool.accdb” database (see figure below). If successfully linked, 11 tables will be linked.

## ***Nonpoint Oil and Gas Emissions Estimation Tool***



- 4) Once you have identified the location of the "area\_bridgetool.accdb" database to link, click on the "Link Tables" button. If successful, 11 tables will be linked. When finished click on the "When finished, Click here." button.



- 5) Click the "BEGIN (go to DASHBOARD VIEW)" button to go to the Dashboard View.
- 6) In the Dashboard View, there are 10 tabs labeled Steps 1 through 10. The User will need to follow all ten steps in order to generate the emission estimates.

### **4.2 Steps to Generate Emissions**

- 1) Step 1 - Select the Geographic Level. In Step 1, the User selects the geographic-level of the emissions inventory based on interest. On this page, the User will see some of the Geographic Area Type maps, which include: EIA Supply Region; EPA Regional Offices; NEMS Regions; Ozone Attainment Status; Regional Planning Organization; or Subpart W Basin. Most Users will select the "STATE" view. When finished, click the "When finished, click here to complete this step." button. A message box will appear instructing the User to proceed to Step 2.

## Nonpoint Oil and Gas Emissions Estimation Tool

**Geographic and Source Selections**

### Oil and Gas Tool: Exploration Activities - Dashboard View

Back to Home Page | Reset All Selections | EXIT TOOL

Step 6 - View/Edit Basin Factors | Step 7 - View/Edit Emission Factors | Step 8 - Point Source Activity Adjustments | Step 9 - Point Source Emission Adjustments | Step 10 - Final Emissions | Master References

Step 1 - Select Geographic Level | Step 2 - Select Specific Geographic Location | Step 3 - Select Source Category Level | Step 4 - Select Specific Source Category | Step 5 - View/Edit County-Level Activity Data

Please select the geographic level at which you are generating emission estimates.

AREA_TYPE	PICK_ONE
EIA SUPPLY REGION	<input type="checkbox"/>
EPA REGION	<input type="checkbox"/>
NATIONWIDE	<input type="checkbox"/>
NEMS REGION	<input checked="" type="checkbox"/>
OZONE ATTAINMENT STATUS	<input type="checkbox"/>
REGIONAL PLANNING ORGANIZATION	<input type="checkbox"/>
STATE	<input type="checkbox"/>
SUBPART W BASIN	<input type="checkbox"/>
*	<input type="checkbox"/>

Record: 14 | 4 of 8 | No Filter | Search

When finished, click here to complete this step.

After making the selection, click this button.

**EIA Supply Region**

Source: U.S. Energy Information Administration Office of Energy Analysis

2) **Step 2 – Select Specific Geographic Location.** Click the “Step 2 – Select Specific Geographic Location” tab to continue. In Step 2, the User selects the specific geographic location of interest. The User may select more than specific location. When finished, click the “When finished, click here to complete this step.” button. A message box will appear instructing the User to proceed to Step 3.

**Geographic and Source Selections**

### Oil and Gas Tool: Exploration Activities - Dashboard View

Back to Home Page | Reset All Selections/Go to Step 1 | EXIT TOOL

Step 6 - View/Edit Basin Factors | Step 7 - View/Edit Emission Factors | Step 8 - Point Source Activity Adjustments | Step 9 - Point Source Emission Adjustments | Step 10 - Final Emissions | Master References

Step 1 - Select Geographic Level | Step 2 - Select Specific Geographic Location | Step 3 - Select Source Category Level | Step 4 - Select Specific Source Category | Step 5 - View/Edit County-Level Activity Data

Please select the specific geographic location at which you are generating emission estimates.

AREA_TYPE	AREA_DESCRIPTION	STATE_NAME	PICK_AT_LEAST_ONE
STATE	AK	Alaska	<input type="checkbox"/>
STATE	AL	Alabama	<input type="checkbox"/>
STATE	AR	Arkansas	<input type="checkbox"/>
STATE	AZ	Arizona	<input type="checkbox"/>
STATE	CA	California	<input type="checkbox"/>
STATE	CO	Colorado	<input type="checkbox"/>
STATE	CT	Connecticut	<input type="checkbox"/>
STATE	DC	District Of Columbia	<input type="checkbox"/>
STATE	DE	Delaware	<input type="checkbox"/>
STATE	FL	Florida	<input type="checkbox"/>
STATE	GA	Georgia	<input type="checkbox"/>
STATE	HI	Hawaii	<input type="checkbox"/>
STATE	IA	Iowa	<input type="checkbox"/>
STATE	ID	Idaho	<input type="checkbox"/>
STATE	IL	Illinois	<input type="checkbox"/>
STATE	IN	Indiana	<input type="checkbox"/>
STATE	KS	Kansas	<input type="checkbox"/>
STATE	KY	Kentucky	<input type="checkbox"/>
STATE	LA	Louisiana	<input type="checkbox"/>
STATE	MA	Massachusetts	<input type="checkbox"/>
STATE	MD	Maryland	<input type="checkbox"/>
STATE	ME	Maine	<input type="checkbox"/>
STATE	MI	Michigan	<input type="checkbox"/>
STATE	MN	Minnesota	<input type="checkbox"/>
STATE	MO	Missouri	<input type="checkbox"/>
STATE	MS	Mississippi	<input type="checkbox"/>
STATE	MT	Montana	<input type="checkbox"/>
STATE	NC	North Carolina	<input type="checkbox"/>
STATE	ND	North Dakota	<input type="checkbox"/>

Record: 14 | 1 of 53 | No Filter | Search

Step 2 – Select the specific geographic location(s)

When finished, click here to complete this step.

After making the selection(s), click this button.

3) **Step 3 – Select the Source Category Level.** Click the “Step 3 – Select Source Category Level” tab to continue. In Step 3, the User can either pick to generate emission estimates for all oil and gas exploration source categories or



## **Nonpoint Oil and Gas Emissions Estimation Tool**

individually select source categories. When finished, click the “When finished, click here to complete this step.” button. A message box will appear instructing the User to proceed to Step 4.

**Oil and Gas Tool: Exploration Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Emission Factors   Step 8 - Point Source Activity Adjustments   Step 9 - Point Source Emission Adjustments   Step 10 - Final Emissions   Master References

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category Level   Step 4 - Select Specific Source Category   Step 5 - View/Edit County-Level Activity Data

Please select the source category level at which you are generating emission estimates.

SOURCE_CATEGORY	PICK_ONE
ALL OIL AND GAS EXPLORATION SOURCE CATEGORIES	<input type="checkbox"/>
SELECT OIL AND GAS EXPLORATION SOURCE CATEGORIES	<input type="checkbox"/>
*	<input type="checkbox"/>

When finished, click here to complete this step.

After making the selection(s), click this button.

4) **Step 4 – Select Specific Source Category.** Click the “Step 4 – Select Specific Source Category” tab to continue. In Step 4, the User can select the specific Source Categories to generate emission estimates. If in Step 3, the User selected “ALL OIL AND GAS EXPLORATION SOURCE CATEGORIES”, then all source categories will be checked. At this point, the User may choose to deselect certain source categories. When finished, click the “When finished, press here” button. A message box will appear instructing the User to proceed to Steps 5, 6, and 7 to review/edit the activity data, basin factors, and emission factors; or to proceed directly to Step 8 for Point Source Activity Adjustments.

**Oil and Gas Tool: Exploration Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Emission Factors   Step 8 - Point Source Activity Adjustments   Step 9 - Point Source Emission Adjustments   Step 10 - Final Emissions   Master References

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category Level   Step 4 - Select Specific Source Category   Step 5 - View/Edit County-Level Activity Data

Please select the specific source categor(ies) for which you are generating emission estimates.

SOURCE_CATEGORY	SCC	SCC_DESCRIPTION	PICK_AT_LEAST_ONE
DRILL RIGS	2310000220	Oil And Gas Exploration Drill Rigs	<input checked="" type="checkbox"/>
HYDRAULIC FRACTURING	2310000660	Oil & Gas Expl & Prod /All Processes /Hydraulic Fracturing Engines	<input checked="" type="checkbox"/>
MUD DEGASSING	2310023606	On-Shore CBM Exploration /Mud Degassing	<input checked="" type="checkbox"/>
MUD DEGASSING	2310111100	On-Shore Oil Exploration /Mud Degassing	<input checked="" type="checkbox"/>
MUD DEGASSING	2310121100	On-Shore Gas Exploration /Mud Degassing	<input checked="" type="checkbox"/>
WELL COMPLETIONS	2310023600	On-Shore CBM Exploration: CBM Well Completion: All Processes	<input checked="" type="checkbox"/>
WELL COMPLETIONS	2310111700	On-Shore Oil Exploration: Oil Well Completion: All Processes	<input checked="" type="checkbox"/>
WELL COMPLETIONS	2310121700	On-Shore Gas Exploration: Gas Well Completion: All Processes	<input checked="" type="checkbox"/>
*			

When finished, press here

After making the selection(s), click this button.

If in Step 3, the User selected “SELECT OIL AND GAS EXPLORATION SOURCE CATEGORIES”, then no source categories will be checked. At this point, the User will select one or more source categories. When finished, click the “When finished, press here” button. A message box will appear instructing the User to proceed to Steps 5, 6, and 7 to

## **Nonpoint Oil and Gas Emissions Estimation Tool**

review/edit the activity data, basin factors, and emission factors; or to proceed directly to Step 8 for Point Source Activity Adjustments.

**Oil and Gas Tool: Exploration Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Emission Factors   Step 8 - Point Source Activity Adjustments   Step 9 - Point Source Emission Adjustments   Step 10 - Final Emissions   Master References

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category Level   **Step 4 - Select Specific Source Category**   Step 5 - View/Edit County-Level Activity Data

Please select the specific source categor(ies) for which you are generating emission estimates.

SOURCE_CATEGORY	SCC	SCC_DESCRIPTION	PICK_AT_LEAST_ONE
DRILL RIGS	2310000220	Oil And Gas Exploration Drill Rigs	<input type="checkbox"/>
HYDRAULIC FRACTURING	2310000660	Oil & Gas Expl & Prod /All Processes /Hydraulic Fracturing Engines	<input type="checkbox"/>
MUD DEGASSING	2310023606	On-Shore CBM Exploration /Mud Degassing	<input type="checkbox"/>
MUD DEGASSING	2310111100	On-Shore Oil Exploration /Mud Degassing	<input type="checkbox"/>
MUD DEGASSING	2310121100	On-Shore Gas Exploration /Mud Degassing	<input type="checkbox"/>
WELL COMPLETIONS	2310023600	On-Shore CBM Exploration: CBM Well Completion: All Processes	<input type="checkbox"/>
WELL COMPLETIONS	2310111700	On-Shore Oil Exploration: Oil Well Completion: All Processes	<input type="checkbox"/>
WELL COMPLETIONS	2310121700	On-Shore Gas Exploration: Gas Well Completion: All Processes	<input type="checkbox"/>
*			<input type="checkbox"/>

When finished, press here

After making the selection(s), click this button.

5) Step 5 – View/Edit County-Level Activity Data. Click the “Step 5 – View/Edit County-Level Activity Data” tab to continue. In Step 5, the User can view and edit the activity data that EPA has compiled for the geographic area and source categories selected.

**Oil and Gas Tool: Exploration Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Emission Factors   Step 8 - Point Source Activity Adjustments   Step 9 - Point Source Emission Adjustments   Step 10 - Final Emissions   Master References

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category Level   Step 4 - Select Specific Source Category   **Step 5 - View/Edit County-Level Activity Data**

Please select the source category you would like to view/edit.

**Oil and Gas Exploration Sources - County-Level Activity Data**

Click on the county-level data set you wish to view/edit.

Drilling and Mud Degassing Activity   Well Completions and Hydraulic Fracturing Activity

When finished, please continue to Step 6 to View/Edit Basin Factors.

Pick a type of production dataset

To continue with this step, the User will need to pick an activity dataset to view/edit. If the “Drilling and Mud Degassing Activity” button is chosen, the User will then be asked to choose a well type.



## Nonpoint Oil and Gas Emissions Estimation Tool

Geographic and Source Selections County Level Activity Data Sets

### COUNTY-LEVEL DRILLING AND MUD DEGASSING ACTIVITY DATA ENTRY FORM

Click on the county-level well type data set you wish to view/edit.

Oil Wells Gas Wells CBM Wells

When finished, click here

Once the well type is selected, an Activity Data form will appear that the User can view or edit. To get to the next county, at the bottom of the screen is the record number. Use the triangle arrows to move through the counties.

Geographic and Source Selections County Level Activity Data Sets Activity Data - Oil Wells

### COUNTY-LEVEL DRILLING AND MUD DEGASSING ACTIVITY DATA ENTRY FORM - OIL WELLS

State Abbreviation AR  
State and County FIPs Code 05027  
County Name Columbia  
Basin Name Louisiana-Mississippi Salt Basins  
Year 2020

Filter for this Basin only Remove Basin Filter

Import/Export Data...

	Current Value	Current Value Reference	2017 Value	2017 Reference	
County-Level Oil Well Spud Counts, Vertical Drilled Wells	0	ENVERUS_2021	0	HPDI_2018	Mud Degassing
County-Level Oil Well Spud Counts, Horizontal Drilled Wells	0	ENVERUS_2021	0	HPDI_2018	Mud Degassing
County-Level Oil Well Spud Counts, Directional Drilled Wells	0	ENVERUS_2021	0	HPDI_2018	Mud Degassing
County-Level Oil Well Spud Counts, Unknown Drilled Wells	2	ENVERUS_2021	0	HPDI_2018	Mud Degassing
County-Level Oil Well Depth Drilled, Vertical Drilled Wells	0.00	AVG_WELL_DEPTH_AR	16,628.57	HPDI_2018_RIGDATA	Drilling Rigs
County-Level Oil Well Depth Drilled, Horizontal Drilled Wells	0.00	AVG_WELL_DEPTH_AR	0.00	HPDI_2018_RIGDATA	Drilling Rigs
County-Level Oil Well Depth Drilled, Directional Drilled Wells	0.00	AVG_WELL_DEPTH_AR	0.00	HPDI_2018_RIGDATA	Drilling Rigs
County-Level Oil Well Depth Drilled, Unknown Drilled Wells	12,208.00	AVG_WELL_DEPTH_AR	0.00	HPDI_2018_RIGDATA	Drilling Rigs

If new values are entered, please enter a reference.

When finished, click here

The User may also edit activity data in MS-Excel by using the "Import/Export Data..." button.

## Nonpoint Oil and Gas Emissions Estimation Tool

Geographic and Source Selections | County Level Activity Data Sets | Activity Data - Oil Wells

### COUNTY-LEVEL DRILLING AND MUD DEGASSING ACTIVITY DATA ENTRY FORM - OIL WELLS

State Abbreviation:   
 State and County FIPS Code:   
 County Name:   
 Basin Name:     
 Year:

Values here can be edited →

	Current Value	Current Value Reference	2017 Value	2017 Reference	Applicable Source Categories
County-Level Oil Well Spud Counts, Vertical Drilled Wells	0	ENVERUS_2021	3	HPDI_2018	Mud Degassing
County-Level Oil Well Spud Counts, Horizontal Drilled Wells	0	ENVERUS_2021	0	HPDI_2018	Mud Degassing
County-Level Oil Well Spud Counts, Directional Drilled Wells	0	ENVERUS_2021	0	HPDI_2018	Mud Degassing
County-Level Oil Well Spud Counts, Unknown Drilled Wells	2	ENVERUS_2021	0	HPDI_2018	Mud Degassing
County-Level Oil Well Depth Drilled, Vertical Drilled Wells	0.00	AVG_WELL_DEPTH_AR	16,628.57	HPDI_2018_RIGDATA	Drilling Rigs
County-Level Oil Well Depth Drilled, Horizontal Drilled Wells	0.00	AVG_WELL_DEPTH_AR	0.00	HPDI_2018_RIGDATA	Drilling Rigs
County-Level Oil Well Depth Drilled, Directional Drilled Wells	0.00	AVG_WELL_DEPTH_AR	0.00	HPDI_2018_RIGDATA	Drilling Rigs
County-Level Oil Well Depth Drilled, Unknown Drilled Wells	12,208.00	AVG_WELL_DEPTH_AR	0.00	HPDI_2018_RIGDATA	Drilling Rigs

When finished, click here

If the user elects to edit activity data in MS-Excel, after clicking the button, the data is then exported into MS-Excel as shown below.

Import/Export Data

### Import/Export Data Data Activity Oil Well

Export Import ? Help

Export the data to an Excel file

Step 1 – Export activity data to Excel.  
(It is recommended that you save this file for later upload.)

A MS-Excel workbook will open when finished exporting. It is required that the User save this file to the hard drive for later upload. In the Excel file, the User can only edit the yellow shaded cells. When completed, simply save the file.

## Nonpoint Oil and Gas Emissions Estimation Tool

STATE_A	STATE_COUNTY	COUNTY_NAME	BASIN	YEA	DATA_CATEGORY	PREVIOUS_VAL	PREVIOUS_REFER	CURRENT_VAL	CURRENT_REFERENC
AR	05001	Arkansas	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05001	Arkansas	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05003	Ashley	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05003	Ashley	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018_RIGDATA	0	ENVERUS_2021
AR	05005	Baxter	Ozark Uplift	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05005	Baxter	Ozark Uplift	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05007	Benton	Ozark Uplift	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05007	Benton	Ozark Uplift	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05009	Boone	Ozark Uplift	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05009	Boone	Ozark Uplift	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05011	Bradley	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05011	Bradley	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05013	Calhoun	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05013	Calhoun	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05015	Carroll	Ozark Uplift	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05015	Carroll	Ozark Uplift	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05017	Chicot	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05017	Chicot	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05019	Clark	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05019	Clark	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05021	Clay	Illinois Basin	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05021	Clay	Illinois Basin	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05023	Cleburne	Arkoma Basin	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05023	Cleburne	Arkoma Basin	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018_RIGDATA	0	ENVERUS_2021
AR	05025	Cleveland	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05025	Cleveland	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05027	Columbia	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021
AR	05027	Columbia	Louisiana-Mississippi Salt Basins	2020	County-Level Oil Well Depth Drilled, Unknown Drilled Wells	0	HPDL_2018_RIGDATA	12208	AVG_WELL_DEPTH_AR
AR	05029	Conway	Arkoma Basin	2020	County-Level Oil Well Spud Counts, Unknown Drilled Wells	0	HPDL_2018	0	ENVERUS_2021

Step 2 – The User can edit the yellow-shaded cells.

If data edits were made, then the User will need to go back to the Tool and click on the “Import/Export Data...” button to initiate importing the edited data file. After clicking, the Import/Export form will appear. The User will need to:

- Step 1 - Click on the “Import” tab,
- Step 2 - Click the “Select File” button
- Step 3 – Map to the location of the edited data, and click “OK”
- Step 4 – Click on the “Import from Excel” button

The screenshot shows the 'Import/Export Data' form for 'Data Activity Oil Well'. It includes a 'Close Form' button and tabs for 'Export', 'Import', and 'Help'. The 'Import' tab is selected. Below the tabs, there is a section titled 'Import the Selected Excel File' with a text box containing the file path 'C:\WORK\OIL\_GAS\RE\_ENGINEERING\ITERATION\_009\_2014\_NEI'. To the left of this text box is an 'Import From Excel' button with an Excel icon. To the right is a 'Select File' button with a magnifying glass icon. Annotations with arrows point to these elements: Step 1 points to the 'Import' tab; Step 2 points to the 'Select File' button; Step 3 points to the file path text box; and Step 4 points to the 'Import From Excel' button.

The edited data is now imported into the Tool.

6) Step 6 – View/Edit Basin Factors. Click the “Step 6 – View/Edit Basin Factors” tab to continue. In Step 6, the User can view and edit the basin factor data that EPA has compiled for the geographic area and source categories selected.

## Nonpoint Oil and Gas Emissions Estimation Tool

**Geographic and Source Selections**

**Oil and Gas Tool: Exploration**

Back to Home Page    Reset All Selections

Step 1 - Select Geographic Level    Step 2 - Select Specific Source Category    Step 3 - Select Specific Source Category    Step 4 - Select Specific Source Category    Step 5 - View/Edit County-Level Activity Data  
 Step 6 - View/Edit Basin Factors    Step 7 - View/Edit Emission Factors    Step 8 - View/Edit Emission Factors    Step 9 - Point Source Emission Adjustments    Step 10 - Final Emissions    Master References

Please select the source category you would like to view/edit:

**Oil and Gas Exploration Sources - Basin Factors**

Please click on the source category below to view/edit the basin factors.

Drill Rigs Horizontal    Drill Rigs Vertical

Hydraulic Fracturing

Mud Degassing

Well Completions

Please click on the source category below to view/edit the gas composition data.

Mud Degassing Gas Composition Data

Well Completions Gas Composition Data

When finished, please continue to Step 7 to View/Edit Emission Factors

When finished, continue to Step 7.

In the Basin Factors form, the User can view/edit the data. If the User updates values for one county in a basin, then all other counties in the basin and state can be updated by clicking on the "Click to apply these values to all other counties in the same basin for the state." button. Additionally, the User can export and import data to MS-Excel similar to the procedure outlined in Step 5.

**Geographic and Source Selections**    **Basin Factors - Horizontal Drilling**

**HORIZONTAL DRILLING RIGS BASIN FACTORS FORM**

State Abbreviation: AR

State and County FIPs Code: 05027

County Name: Columbia

Basin Name: Louisiana-Mississippi Salt Basins

Filter for this Basin only    Remove Basin Filter

The User can export and import the data into MS-Excel.    Import/Export Data...

Click here to apply these values to all other counties in the same basin for this state.

When finished, click here

If new values are entered, please enter a reference.

EPA default values cannot be edited.

Values from the 2017 Tool. Values here cannot be edited.

	Current Value	Current Value Reference	EPA Default Value	EPA Default Value Reference	2017 Value	2017 Value Reference
Horizontal-Drill Rig Spud Depth (ft/spud)	8800.0	CENSARA_STUDY_2012	8690.0	CENSARA_STUDY_2012_AVERAGE	8800.0	CENSARA_STUDY_2012
Horizontal-Drill Rig Spud Duration (hrs)	165	CENSARA_STUDY_2012	526	CENSARA_STUDY_2012_AVERAGE	165	CENSARA_STUDY_2012
Horizontal-Drill Rig Fuel Consumed (gallons)	7.45	CENSARA_STUDY_2012	30.73	CENSARA_STUDY_2012_AVERAGE	7.45	CENSARA_STUDY_2012
Horizontal-Draw Rig Horsepower (HP)	1122	CENSARA_STUDY_2012	558	CENSARA_STUDY_2012_AVERAGE	1122	CENSARA_STUDY_2012
Horizontal-Draw Rig Load Factor	0.67	CENSARA_STUDY_2012	0.58	CENSARA_STUDY_2012_AVERAGE	0.67	CENSARA_STUDY_2012
Number of Horizontal-Draw Rig Engines (count/rig)	2	CENSARA_STUDY_2012	2	CENSARA_STUDY_2012_AVERAGE	2	CENSARA_STUDY_2012
Horizontal-Draw Spud Duration (hrs/spud)	536.2	CENSARA_STUDY_2012				
Horizontal-Drill Rig Mud Pumps Horsepower (HP)	0	CENSARA_STUDY_2012				
Horizontal-Drill Rig Mud Pumps Load Factor	0	CENSARA_STUDY_2012				
Horizontal-Draw Rig Spud Duration (hrs/spud)	0	CENSARA_STUDY_2012	2	CENSARA_STUDY_2012_AVERAGE		
Horizontal-Draw Rig Spud Duration (hrs/spud)	0	CENSARA_STUDY_2012	130	CENSARA_STUDY_2012_AVERAGE	0	CENSARA_STUDY_2012
Horizontal-Draw Rig Spud Duration (hrs/spud)	0	CENSARA_STUDY_2012	772	CENSARA_STUDY_2012_AVERAGE	0	CENSARA_STUDY_2012
Diesel-Horizontal Drill Rigs Load Factor	0	CENSARA_STUDY_2012	0.6	CENSARA_STUDY_2012_AVERAGE	0	CENSARA_STUDY_2012
Diesel-Horizontal Drill Rigs Number of Engines (count/rig)	0	CENSARA_STUDY_2012	2	CENSARA_STUDY_2012_AVERAGE	0	CENSARA_STUDY_2012
Diesel-Horizontal Drill Rigs Spud Duration (hrs/spud)	0	CENSARA_STUDY_2012	200	CENSARA_STUDY_2012_AVERAGE	0	CENSARA_STUDY_2012
Diesel-Electric-Horizontal Drill Rigs Horsepower (HP)	0	CENSARA_STUDY_2012	1500	CENSARA_STUDY_2012_AVERAGE	0	CENSARA_STUDY_2012
Diesel-Electric-Horizontal Drill Rigs Load Factor	0	CENSARA_STUDY_2012			0	CENSARA_STUDY_2012
Diesel-Electric-Horizontal Drill Number of Engines (count/rig)	0	CENSARA_STUDY_2012	3	CENSARA_STUDY_2012_AVERAGE	0	CENSARA_STUDY_2012
Diesel-Electric-Horizontal Drill Spud Duration (hrs/spud)	0	CENSARA_STUDY_2012	0	CENSARA_STUDY_2012_AVERAGE	0	CENSARA_STUDY_2012

Similarly, the User can view/edit the gas composition data for select categories.



## Nonpoint Oil and Gas Emissions Estimation Tool

7) Step 7 – View/Edit Emission Factors. Click the “Step 7 – View/Edit Emission Factors” tab to continue. In Step 7, the User can view or edit the emission factors that are used to generate the emission estimates for the source categories selected.

**Oil and Gas Tool: Exploration Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category   **Step 4 - View/Edit Emission Factors**   Step 5 - View/Edit County-Level Activity Data   Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Emission Factors   Step 8 - Point Source Activity Adjustments   Step 9 - View/Edit Emission Factors   Step 10 - Final Emissions   Master References

Please select the emission factor source category you would like to view/edit.

**Oil and Gas Exploration Sources - Emission Factors**

Please click on a Source Category below to view/edit emission factors.

- Drill Rigs
- Hydraulic Fracturing
- Mud Degassing
- Well Completions

When finished, please continue to Step 8 for Point Source Activity Adjustments

When finished, continue to Step 8.

Once a Source Category has been selected, the User can view or edit the emission factors. Remember to update the reference field (EMISSION\_FACTOR\_SOURCE) for any updated emission factors.

**HYDRAULIC FRACTURING EMISSION FACTORS FORM**

ST	BASIN	ATTAINMENT	SOURCE_CATEGORY	SCC	SCC_SHOI	POLLUTANT	POLLUTANT_DESCR	POLLUTANT	EMISSION_FACTOR	EMISSION_FACTOR_SOURCE	EMISSION_FACTOR_UNITS
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Ethylbenzene	Ethyl Benzene	100414	9.14512E-04	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Styrene	Styrene	100425	2.958528E-04	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex 1,3-Butadiene	1,3-Butadiene	106990	8.873381E-03	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Acrolein	Acrolein	107028	7.290602E-03	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Toluene	Toluene	108883	1.266875E-04	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Hexane	Hexane	110543	2.029268E-05	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Anthracene	Anthracene	120127	5.410304E-03	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Propionaldehyde	Propionaldehyde	123386	3.171553E-05	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Pyrene	Pyrene	129000	2.696867E-03	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Xylenes (Mixed Isomers)	Xylenes (Mixed Isomers)	1330207	6.738941E-09	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Chromium Comp	Chromium (VI)	18540299	1.795181E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Benzo[a,h,i]Perylene	Benzo[a,h,i]Perylene	191242	7.030915E-07	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Indeno[1,2,3-c,d]Pyrene	Indeno[1,2,3-c,d]Pyrene	193395	1.12306E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Fluoranthene	Fluoranthene	205992	3.25717E-05	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Benzo[k]Fluoranthene	Benzo[k]Fluoranthene	207089	8.518818E-07	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Acenaphthylene	Acenaphthylene	208968	2.298891E-04	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Chrysene	Chrysene	218019	2.913389E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Formaldehyde	Formaldehyde	50000	5.897982E-02	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Benzo[a]Pyrene	Benzo[a]Pyrene	50328	7.133008E-07	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Polycyclic Orgs Dibenzo[a,h]Anthracene	Dibenzo[a,h]Anthracene	53703	1.195512E-07	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex		51	1.635179E-03	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex		52	2.30254E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex		53	6.861636E-05	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex		54	1.006927E-02	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex		55	5.391868E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex		56	2.996139E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Mercury Comp	Mercury	7439976	1.854732E-08	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Nickel Comp	Nickel	7440020	5.238648E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Antimony Comp	Antimony	7440360	4.621601E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Arsenic Comp	Arsenic	7440382	3.395385E-09	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Cadmium Comp	Cadmium	7440439	5.35112E-06	G	HP-HR
AR	Arkoma Basin	ATTAINMENT	HYDRAULIC FRACTURING	2310000660		Oil & Gas Ex Cobalt Comp	Cobalt	7440484	1.421156E-06	G	HP-HR

When finished, click here

## **Nonpoint Oil and Gas Emissions Estimation Tool**

8) **Step 8 – Point Source Activity Adjustments.** Click the “Step 8 – Point Source Activity Adjustments” tab to continue. After the activity data, basin factors, and emission factors have been reviewed and/or updated, the User may enter point source activity adjustments to account for emissions that are to be reported to the point sources emissions inventory. If the User does not have any point source activity adjustments, then they will need to click the “When finished, click here to complete this step.” button. A message box will appear instructing the User to proceed to Step 9.

Oil and Gas Tool: Exploration Activities - Dashboard View

Back to Home Page | Reset All Selections/Go to Step 1 | EXIT TOOL

Step 1 - Select Geographic Level | Step 2 - Select Specific Geographic Location | Step 3 - Select Source Category Level | Step 4 - Select Specific Source Category | Step 5 - View/Edit County-Level Activity Data | Step 6 - View/Edit Basin Factors | Step 7 - View/Edit Emission Factors | **Step 8 - Point Source Activity Adjustments** | Step 9 - Point Source Emission Adjustments | Step 10 - Final Emissions | Master References

Please select the source category you would like to view/edit to make point source activity adjustments.

**Oil and Gas Exploration Sources - Point Source Activity Adjustments**

Please click on a Source Category below to view/edit activity data for point sources adjustments.

Select a Source Category to make point source activity adjustments.

- Drill Rigs
- Mud Degassing
- Well Completions/Hydraulic Fracturing

If you created point source activity data adjustments and saved them for later use, please click on a Source Category below to populate

Click a Source Category to apply saved point source activity adjustments.

- Drill Rigs
- Mud Degassing
- Well Completions/Hydraulic Fracturing

Clear all point source activity holding tables

Users can refer to this point/nonpoint SCC crosswalk.

When finished, click here to complete this step.

When finished, click here to proceed to Step 9.

Currently, ALL point source activity adjustments (e.g. county-level point source spud counts, county-level point source feet drilled, county-level well completions, etc.) are defaulted to zero (i.e., no point source activity adjustments).

Geographic and Source Selections | FORM\_WELL\_COMPLETION\_PS\_ACTIVITY

**WELL COMPLETIONS/HYDRAULIC FRACTURING POINT SOURCE ACTIVITY ADJUSTMENT FORM**

State abbreviation: AR

State and County FIPs Code: 05027

County name: Columbia

Year: 2020

	Point Sources Conventional Wells Value	Point Sources Unconventional Wells Value*
Point Source Well Completions from Oil Wells	0	0
Point Source Well Completions from Gas Wells	0	0
Point Source Well Completions from CBM Wells	0	0

When finished, click here

\* Hydraulic Fracturing point source subtractions are accounted for in "Point Sources Unconventional Wells Value"

It is encouraged that point source activity adjustments have priority over point source emission adjustments. Additionally, Users should pay careful attention to ensure that the point source activity data is entered in the

## Nonpoint Oil and Gas Emissions Estimation Tool

**same units as the nonpoint activity data.** Users should refer to the “Nonpoint Source SCCs and Point Source SCCs Crosswalk” button to identify point source SCCs. After any point source activity adjustments have been made, proceed to Step 9.

9) Step 9 – Point Source Emission Adjustments. Click the “Step 9 – Point Source Emission Adjustments” tab to continue. In Step 9, the User can make point source emission adjustments directly in the emission tables. Select a Source Category to open. If a User has no point source emissions adjustments, they may click on the “When finished, click here to complete this step” button.

The screenshot shows the 'Oil and Gas Tool: Exploration Activities - Dashboard View' interface. At the top, there's a navigation bar with tabs for 'Geographic and Source Selections', 'Back to Home Page', 'Reset All Selections/Go to Step 1', and 'EXIT TOOL'. Below this is a progress bar with steps 1 through 10, where Step 9 is highlighted. The main content area is titled 'Oil and Gas Exploration Sources - Point Source Emission Adjustments'. It contains two main sections. The first section, 'Please click on a Source Category below to view/edit calculated emission records for point sources adjustments.', has a box labeled 'Select a Source Category to make point source emission adjustments.' pointing to a list of categories: Drill Rigs, Hydraulic Fracturing, Mud Degassing, and Well Completions. The second section, 'If you created point source emissions data adjustments and saved them for later use, please click on a Source Category below to populate', has a box labeled 'Click a Source Category to apply saved point source emission adjustments.' pointing to the same list of categories. To the right of this list is a button labeled 'Clear all point source emissions holding tables'. On the far right, there is a box labeled 'When finished, click here to complete this step.' with an arrow pointing to it from the bottom right. At the bottom right, there is another box labeled 'When finished, click here to proceed to Step 9.' with an arrow pointing to the 'When finished, click here to complete this step.' box.

Point source emission estimates are to be entered in the “POINT\_EMISSIONS\_TPY” field. **It is important to note that if point source activity adjustments were made in Step 8, then point source emission adjustments should NOT be made in these tables for overlapping SCCs. Also, point source emission adjustments need to be entered as tons per year (TPY).**



## Nonpoint Oil and Gas Emissions Estimation Tool

Geographic and Source Selections FORM: WELL\_COMPLETIONS\_EMISSIONS

**WELL COMPLETIONS POINT SOURCE EMISSIONS ADJUSTMENT**

When finished, click here to finalize the emissions.

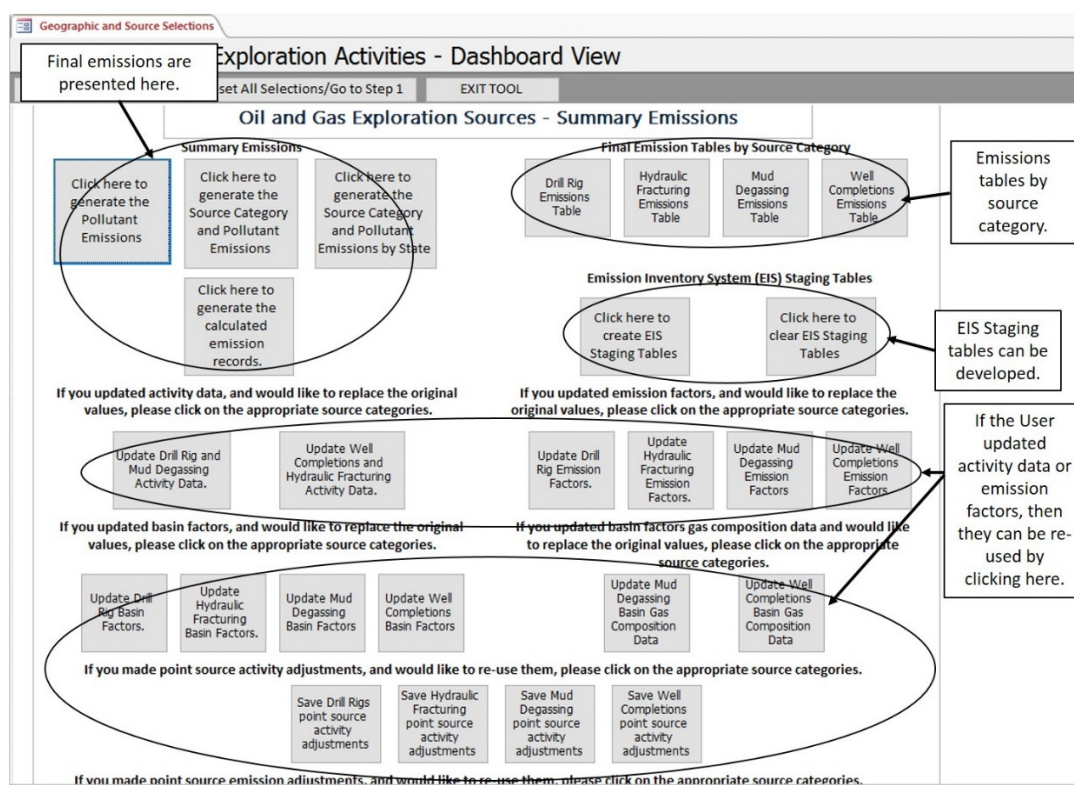
Users can enter point source emissions adjustments

STATE_COUNTY_FIPS	STATE_ABBR	COUNTY_NAME	SCC	SOURCE_CATEGORY	POLLUTANT_CODE	POINT_EMISSIONS_TPY
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	100414	Ethyl B
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	108883	Toluene
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	1330207	Xylenes
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	50000	Formal
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	71432	Benzen
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	7783064	Hydrog
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	CH4	Methan
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	CO	Carbon
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	CO2	Carbon
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	N2O	Nitros
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	NOx	Nitros
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	SO2	Sulfur
48439	TX	Tarrant	2310111700	WELL_COMPLETIONS	VOC	Volatil
48439	TX	Tarrant	2310121700	WELL_COMPLETIONS	100414	Ethyl B
48439	TX	Tarrant				Toluene
48439	TX	Tarrant				Xylenes (Mixed Isomers)
48439	TX	Tarrant				Formaldehyde
48439	TX	Tarrant				Benzene
48439	TX	Tarrant				Hydrogen Sulfide
48439	TX	Tarrant				Methane
48439	TX	Tarrant				Carbon Monoxide
48439	TX	Tarrant				Carbon Dioxide
48439	TX	Tarrant				Nitrous Oxide
48439	TX	Tarrant				Nitrogen Oxides
48439	TX	Tarrant				Sulfur Dioxide
48439	TX	Tarrant				Volatile Organic Compound
48439	TX	Tarrant				Ethyl Benzene
48439	TX	Tarrant				Toluene
48439	TX	Tarrant				Xylenes (Mixed Isomers)
48439	TX	Tarrant				Formaldehyde

Records: 14 of 7800

After point source emission adjustments are made (if applicable), then the User should proceed to Step 10.

10) **Step 10 – Final Emissions.** Click the “Step 10 – Final Emissions” tab to continue. In Step 10, the User can review the final emissions, update county-level activity data, emission factors, and basin factors that the User updated, retain point source activity and/or point source emission adjustments, or generate the Emission Inventory System (EIS) data tables.



Additional notes:



## Nonpoint Oil and Gas Emissions Estimation Tool

- 1) In the EIS Staging Tables, the ControlApproach, ControlMeasure, ControlPollutant, Emissions, EmissionsProcess, Location, and ReportingPeriod are populated.
- 2) EPA's EIS area\_bridgetool (included in the .zip file) can be used to generate the .xml file needed for EIS upload.
- 3) If the User wishes to reset the tool, and regenerate the emissions, the following steps are recommended:
  - a. Click on the "Reset All Selections/Go to Step 1" button at the top of the Dashboard.
  - b. Compact and Repair the database.

**Oil and Gas Tool: Exploration Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category Level   Step 4 - Select Specific Source Category   Step 5 - View/Edit County-Level Activity Data  
 Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Emission Factors   Step 8 - Point Source Activity Adjustments   Step 9 - Point Source Emission Adjustments   Step 10 - Final Emissions   Master References

Please select the type of summary emissions you would like to view, or to generate the EIS Staging tables.

**Oil and Gas Exploration Sources - Summary Emissions**

To return to the Home page, click here.

To reset the Tool, please click here.

To exit the Tool, click here.

Click here to generate the Source Category and Pollutant Emissions

Click here to generate the calculated emission records.

Drill Rig Emissions Table

Hydraulic Fracturing Emissions Table

Mud Degassing Emissions Table

Well Completions Emissions Table

**Emission Inventory System (EIS) Staging Tables**

Click here to create EIS Staging Tables

Click here to clear EIS Staging Tables

If you updated activity data, and would like to replace the original values, please click on the appropriate source categories.

If you updated emission factors, and would like to replace the original values, please click on the appropriate source categories.

- 4) References cited for the original data in the Tool are found in the "Master References" tab.

FIELD_REFERENCE	FIELD_REFERENCE_DESCRIPTION
ALOGC_2021	Alabama Oil and Gas Commission. Exploration data downloaded November 2021
API_2009b	API Compendium (8/2009), Table 4-11
AVG_WELL_DEPTH_AR	Calculated avg feet per well for Arkansas wells and applied to missing wells
AVG_WELL_DEPTH_CA	Calculated avg feet per well for California wells and applied to missing wells
AVG_WELL_DEPTH_CO	Calculated avg feet per well for Colorado wells and applied to missing wells
AVG_WELL_DEPTH_KS	Calculated avg feet per well for Kansas wells and applied to missing wells
AVG_WELL_DEPTH_LA	Calculated avg feet per well for Louisiana wells and applied to missing wells
AVG_WELL_DEPTH_MI	Calculated avg feet per well for Michigan wells and applied to missing wells
AVG_WELL_DEPTH_ND	Calculated avg feet per well for North Dakota wells and applied to missing wells
AVG_WELL_DEPTH_OH	Calculated avg feet per well for Ohio wells and applied to missing wells
AVG_WELL_DEPTH_OK	Calculated avg feet per well for Oklahoma wells and applied to missing wells
AVG_WELL_DEPTH_PA	Calculated avg feet per well for Pennsylvania wells and applied to missing wells
AVG_WELL_DEPTH_TX	Calculated avg feet per well for Texas wells and applied to missing wells
AVG_WELL_DEPTH_WY	Calculated avg feet per well for Wyoming wells and applied to missing wells

**APPENDIX B – INSTRUCTIONS FOR USING THE EPA NONPOINT OIL AND GAS EMISSIONS  
ESTIMATION TOOL, PRODUCTION MODULE (12/2/2021)**

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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### **Instructions for Using the 2020 EPA Nonpoint Oil and Gas Emissions Estimation Tool, Production Module (12/2/2021)**

#### **1.0 Introduction**

Under Work Assignment with U.S. EPA, Eastern Research Group, Inc. (ERG) was tasked to develop a tool that state, local, and tribal (SLT) agencies could use to develop a nonpoint source emission inventory for upstream oil and natural gas activities. To this end, ERG prepared the EPA Nonpoint Oil and Gas Emissions Estimation Tool for the 2011 base year to assist agencies in compiling, allocating, and adjusting upstream oil and natural gas activity data, and developing county-level nonpoint source emission estimates.

In support of the 2014 NEI, U.S. EPA directed ERG to redesign the Tool to enhance the User experience. Such enhancements included, but were not limited to: 1) the development of a “Dashboard View” to guide the User; 2) the creation of data entry forms; 3) the creation of a MS Excel-based data import/export utility; 4) ability to view EPA default data; and 5) more flexibility in how data are presented. As part of this work and to increase the efficiency, the Tool was split into two separate modules (i.e., two separate databases): exploration activities and production activities. These instructions address use of the exploration module.

For the 2017 NEI, U.S. EPA directed ERG to build upon the re-engineered Production and Exploration Tools to reflect 2017 activity, as well as include additional PM species, update county FIPS code changes, and include new source categories and pollutants, when available.

For the 2020 NEI, EPA included basin-level speciation and non-speciation factor updates. The tool generated estimates for 57 source classification codes (SCCs) and 70 pollutants. Where state or local data were not submitted to the NEI, EPA uses the estimates generated for inclusion in the 2020 NEI.

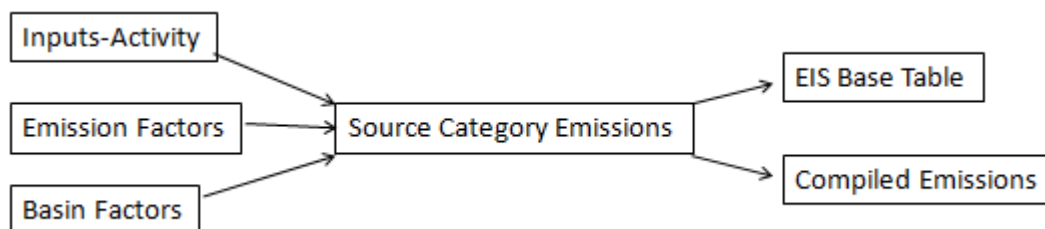
#### **2.0 MS-Access Databases**

The Nonpoint Oil and Gas Emissions Estimation Tools were programmed in MS-Access. This platform offered several advantages, particularly in accessibility (software is available to most users), familiarity (MS-Access is used by most SLT agencies in preparation of Emission Inventory System (EIS) data files), and portability (the tool modules can be e-mailed as zipped files that are less than 25 MB each in size).

Included with the tool are the “area\_bridgetool” blank staging tables which are to be used for preparation of EIS data files.

#### **3.0 Tool Data Flow**

The basic concept of the tool is to calculate the source category emissions using the activity data, emission factors, and basin factors. A conceptual flow is:



#### **4.0 Steps for Using the Oil and Natural Gas Tool for Production Sources to Generate Emissions**

In this section, steps will be outlined to generate emissions from the Production sources.

## **Nonpoint Oil and Gas Emissions Estimation Tool**

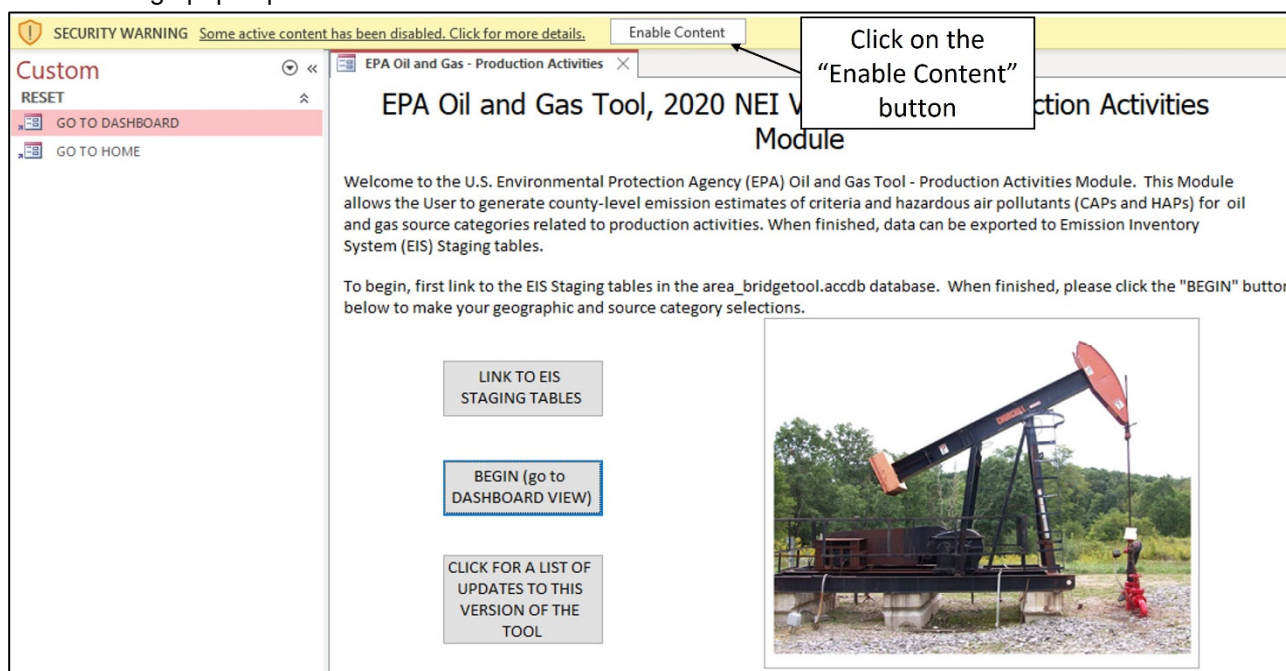
Note: If the User will be editing an existing version of the database and wishes to reset the tool and regenerate the emissions, the following steps are recommended:

- c. Click on the “Reset All Selections/Go to Step 1” button at the top of the Dashboard; and
- d. Compact and Repair the database

### **Preparation**

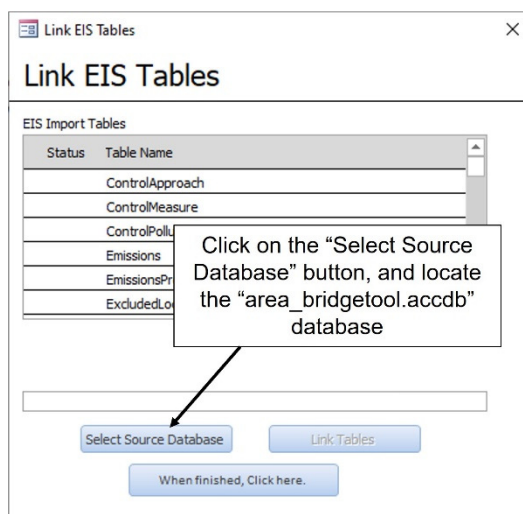
Prior to running the tool, the User must properly link the data tables in the Nonpoint Emissions Staging Tables within the tool. To do this, follow the instructions below:

- 1) Place both the “OIL\_GAS\_TOOL\_2020\_NEI\_PRODUCTION\_V1\_1.accdb” and the “area\_bridgetool.accdb” database tables in the same directory. It is recommended that the User creates an “EPA\_OIL\_GAS” directory on their hard drive.
- 2) Open the “OIL\_GAS\_TOOL\_2020\_NEI\_PRODUCTION\_V1\_1.accdb” database. You will need to “Enable Macros” if the message pops up.

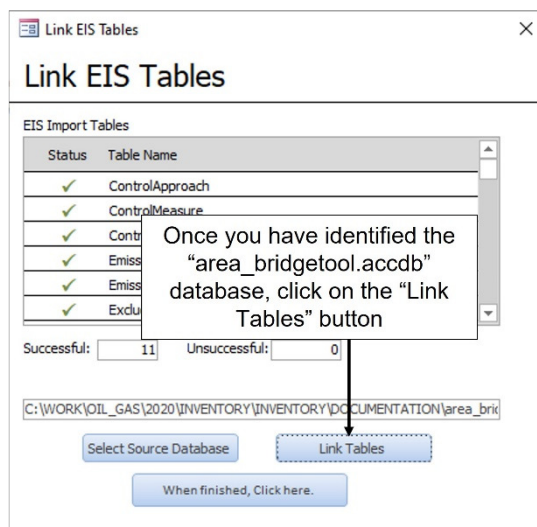


- 3) Click on the “LINK TO EIS STAGING TABLES” button, and a pop-up box will appear. Follow the instructions to link in the EIS Staging tables in the “area\_bridgetool.accdb” database (see figure below). If successfully linked, 11 tables will be linked.

## ***Nonpoint Oil and Gas Emissions Estimation Tool***



- 4) Once you have identified the location of the "area\_bridgetool.accdb" database to link, click on the "Link Tables" button. If successful, 11 tables will be linked. When finished click on the "When finished, Click here." button.



- 5) Click the "BEGIN (go to DASHBOARD VIEW)" button to go to the Dashboard View.
- 6) In the Dashboard View, there are 10 tabs labeled Steps 1 through 10. The User will need to follow all ten steps in order to generate the emission estimates.

### **4.1 Steps to Generate Emissions**

- 1) Step 1 - Select the Geographic Level. In Step 1, the User selects the geographic-level of the emissions inventory based on interest. On this page, the User will see some of the Geographic Area Type maps, which include: EIA Supply Region; EPA Regional Offices; NEMS Regions; Ozone Attainment Status; Regional Planning Organization; or Subpart W Basin. Most Users will select the "STATE" view. When finished, click the "When finished, click here to complete this step." button. A message box will appear instructing the User to proceed to Step 2.

## Nonpoint Oil and Gas Emissions Estimation Tool

**Geographic and Source Selections**

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page    Reset All Selections/Go to Step 1    EXIT TOOL

Step 6 - View/Edit Basin Factors    Step 7 - View/Edit Emission Factors    Step 8 - Point Source Activity Adjustments    Step 9 - Point Source Emission Adjustments    Step 10 - Final Emissions    Master References

Step 1 - Select Geographic Level    Step 2 - Select Specific Geographic Location    Step 3 - Select Source Category Level    Step 4 - Select Specific Source Category    Step 5 - View/Edit County-Level Activity Data

Please select the geographic level at which you are generating emission estimates.

AREA_TYPE	PICK_ONE
EIA SUPPLY REGION	<input type="checkbox"/>
EPA REGION	<input type="checkbox"/>
NATIONWIDE	<input type="checkbox"/>
NEMS REGION	<input checked="" type="checkbox"/>
OZONE ATTAINMENT STATUS	<input type="checkbox"/>
REGIONAL PLANNING ORGANIZATION	<input type="checkbox"/>
STATE	<input type="checkbox"/>
SUBPART W BASIN	<input type="checkbox"/>

Record: 14   4 of 8   No Filter   Search

**EIA Supply Region**

When finished, click here to complete this step.

After making the selection, click this button.

2) **Step 2 – Select Specific Geographic Location.** Click the “Step 2 – Select Specific Geographic Location” tab to continue. In Step 2, the User selects the specific geographic location of interest. The User may select more than specific location. When finished, click the “When finished, click here to complete this step.” button. A message box will appear instructing the User to proceed to Step 3.

**Geographic and Source Selections**

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page    Reset All Selections/Go to Step 1    EXIT TOOL

Step 6 - View/Edit Basin Factors    Step 7 - View/Edit Emission Factors    Step 8 - Point Source Activity Adjustments    Step 9 - Point Source Emission Adjustments    Step 10 - Final Emissions    Master References

Step 1 - Select Geographic Level    Step 2 - Select Specific Geographic Location    Step 3 - Select Source Category Level    Step 4 - Select Specific Source Category    Step 5 - View/Edit County-Level Activity Data

Please select the specific geographic location at which you are generating emission estimates.

AREA_TYPE	AREA_DESCRIPTION	STATE_NAME	PICK_AT_LEAST_ONE	COMMENT
STATE	AK	Alaska	<input type="checkbox"/>	
STATE	AL	Alabama	<input type="checkbox"/>	
STATE	AR	Arkansas	<input type="checkbox"/>	
STATE	AZ	Arizona	<input type="checkbox"/>	
STATE	CA	California	<input type="checkbox"/>	
STATE	CO	Colorado	<input type="checkbox"/>	
STATE	CT	Connecticut	<input type="checkbox"/>	
STATE	DC	District Of Columbia	<input type="checkbox"/>	
STATE	DE	Delaware	<input type="checkbox"/>	
STATE	FL	Florida	<input type="checkbox"/>	
STATE	GA	Georgia	<input type="checkbox"/>	
STATE	HI	Hawaii	<input type="checkbox"/>	
STATE	IA	Iowa	<input type="checkbox"/>	
STATE	ID	Idaho	<input type="checkbox"/>	
STATE	IL	Illinois	<input type="checkbox"/>	
STATE	IN	Indiana	<input type="checkbox"/>	
STATE	KS	Kansas	<input type="checkbox"/>	
STATE	KY	Kentucky	<input type="checkbox"/>	
STATE	LA	Louisiana	<input type="checkbox"/>	
STATE	MA	Massachusetts	<input type="checkbox"/>	
STATE	MD	Maryland	<input type="checkbox"/>	
STATE	ME	Maine	<input type="checkbox"/>	
STATE	MI	Michigan	<input type="checkbox"/>	
STATE	MN	Minnesota	<input type="checkbox"/>	
STATE	MO	Missouri	<input type="checkbox"/>	
STATE	MS	Mississippi	<input type="checkbox"/>	
STATE	MT	Montana	<input type="checkbox"/>	
STATE	NC	North Carolina	<input type="checkbox"/>	
STATE	ND	North Dakota	<input type="checkbox"/>	

Record: 14   1 of 53   No Filter   Search

Step 2 – Select the specific geographic location(s)

When finished, click here to complete this step.

After making the selection(s), click this button.

3) **Step 3 – Select the Source Category Level.** Click the “Step 3 – Select Source Category Level” tab to continue. In Step 3, the User can either pick to generate emission estimates for all oil and gas production source categories or individually select source categories. When finished, click the “When finished, click here to complete this step.” button. A message box will appear instructing the User to proceed to Step 4.



## Nonpoint Oil and Gas Emissions Estimation Tool

**Geographic and Source Selections**

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Emission Factors   Step 8 - Point Source Activity Adjustments   Step 9 - Point Source Activity Adjustments   Master References

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   **Step 3 - Select Source Category Level**   Step 4 - Select Specific Source Category

Please select the source category level at which you are generating emission estimates.

SOURCE_CATEGORY	PICK_ONE
ALL UPSTREAM PRODUCTION OIL AND GAS SOURCE CATEGORIES	<input type="checkbox"/>
SELECT UPSTREAM PRODUCTION OIL AND GAS SOURCE CATEGORIES	<input type="checkbox"/>
*	<input type="checkbox"/>

Record: 1 of 2   No Filter   Search

When finished, click here to complete this step.

After making the selection(s), click this button.

4) **Step 4 – Select Specific Source Category.** Click the “Step 4 – Select Specific Source Category” tab to continue. In Step 4, the User can select the specific Source Categories to generate emission estimates. If in Step 3, the User selected “ALL OIL AND GAS PRODUCTION SOURCE CATEGORIES”, then all source categories will be checked. At this point, the User may choose to deselect certain source categories. When finished, click the “When finished, press here” button. A message box will appear instructing the User to proceed to Steps 5, 6, and 7 to review/edit the activity data, basin factors, and emission factors; or to proceed directly to Step 8 for Point Source Activity Adjustments.

**Geographic and Source Selections**

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 4 – All Source Categories are selected.

SOURCE_CATEGORY	SCC	SCC_DESC	PICK_AT_LEAST_ONE
ARTIFICIAL LIFTS	2310000330	Oil & Gas Expl & Prod /All Processes /Artificial Lift	<input checked="" type="checkbox"/>
ASSOCIATED GAS	2310011000	On Shore Crude Oil Production All Processes	<input checked="" type="checkbox"/>
CBM DEWATERING PUMPS	2310023000	Coal Bed Methane NG / Dewatering Pump Engines	<input checked="" type="checkbox"/>
CONDENSATE TANKS	2310021010	On-Shore Gas Production /Storage Tanks: Condensate	<input checked="" type="checkbox"/>
CONDENSATE TANKS	2310023010	On-Shore CBM Production /Storage Tanks: Condensate	<input checked="" type="checkbox"/>
CRUDE OIL TANKS	2310010200	Oil & Gas Expl & Prod /Crude Petroleum /Oil Well Tanks - Flashing & St	<input checked="" type="checkbox"/>
DEHYDRATORS	2310021400	On-Shore Gas Production Dehydrators	<input checked="" type="checkbox"/>
DEHYDRATORS	2310023400	Coal Bed Methane NG / Dehydrators	<input checked="" type="checkbox"/>
FUGITIVES	2310011501	On-Shore Oil Production /Fugitives: Connectors	<input checked="" type="checkbox"/>
FUGITIVES	2310011502	On-Shore Oil Production /Fugitives: Flanges	<input checked="" type="checkbox"/>
FUGITIVES	2310011503	On-Shore Oil Production /Fugitives: Open Ended Lines	<input checked="" type="checkbox"/>
FUGITIVES	2310011505	On-Shore Oil Production /Fugitives: Valves	<input checked="" type="checkbox"/>
FUGITIVES	2310021501	On-Shore Gas Production /Fugitives: Connectors	<input checked="" type="checkbox"/>
FUGITIVES	2310021502	On-Shore Gas Production /Fugitives: Flanges	<input checked="" type="checkbox"/>
FUGITIVES	2310021503	On-Shore Gas Production /Fugitives: Open Ended Lines	<input checked="" type="checkbox"/>
FUGITIVES	2310021505	On-Shore Gas Production /Fugitives: Valves	<input checked="" type="checkbox"/>
FUGITIVES	2310021506	On-Shore Gas Production /Fugitives: Other	<input checked="" type="checkbox"/>
FUGITIVES	2310023511	On-Shore CBM Production /Fugitives: Connectors	<input checked="" type="checkbox"/>

When finished, press here

After making the selection(s), click this button

If in Step 3, the User selected “SELECT OIL AND GAS PRODUCTION SOURCE CATEGORIES”, then no source categories will be checked. At this point, the User will select one or more source categories. When finished, click the “When finished, press here” button. A message box will appear instructing the User to proceed to Steps 5, 6, and 7 to

## Nonpoint Oil and Gas Emissions Estimation Tool

review/edit the activity data, basin factors, and emission factors; or to proceed directly to Step 8 for Point Source Activity Adjustments.

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page | Reset All Selections/Go to Step 1 | EXIT TOOL

Step 6 - View/Edit Basin Factors | Step 7 - View/Edit Emission Factors | Step 8 - Point Source Activity Adjustments | Step 9 - Point Source Emission Adjustments | Step 10 - Final Emissions  
 Step 1 - Select Geographic Level | Step 2 - Select Specific Geographic Location | Step 3 - Select Source Category Level | Step 4 - Select Specific Source Category | Step 5 - View/Edit County-Level Activity Data

Please select the specific source category(ies) for which you are generating emission estimates for.

SOURCE_CATEGORY	SCC	SCC_DESCRIPTION	PICK_AT_LEAST_ONE
ARTIFICIAL LIFTS	2310000330	Oil & Gas Expl & Prod /All Processes /Artificial Lift	<input checked="" type="checkbox"/>
ASSOCIATED GAS	2310011000	On Shore Crude Oil Production All Processes	<input type="checkbox"/>
CBM DEWATERING PUMPS	2310023000	Coal Bed Methane NG / Dewatering Pump Engines	<input type="checkbox"/>
CONDENSATE TANKS	2310021010	On-Shore Gas Production /Storage Tanks: Condensate	<input type="checkbox"/>
CONDENSATE TANKS	2310023010	On-Shore CBM Production /Storage Tanks: Condensate	<input type="checkbox"/>
CRUDE OIL TANKS	2310010200	Oil & Gas Expl & Prod /Crude Petroleum /Oil Well Tanks - Flashing & Sta	<input type="checkbox"/>
DEHYDRATORS	2310021400	On-Shore Gas Production Dehydrators	<input type="checkbox"/>
DEHYDRATORS	2310023400	Coal Bed Methane NG / Dehydrators	<input type="checkbox"/>
FUGITIVES	2310011501	On-Shore Oil Production /Fugitives: Connectors	<input type="checkbox"/>
FUGITIVES	2310011502	On-Shore Oil Production /Fugitives: Flanges	<input type="checkbox"/>
FUGITIVES	2310011503	On-Shore Oil Production /Fugitives: Open Ended Lines	<input type="checkbox"/>
FUGITIVES	2310011505	On-Shore Oil Production /Fugitives: Valves	<input type="checkbox"/>
FUGITIVES	2310021501	On-Shore Gas Production /Fugitives: Connectors	<input type="checkbox"/>
FUGITIVES	2310021502	On-Shore Gas Production /Fugitives: Flanges	<input type="checkbox"/>
FUGITIVES	2310021503	On-Shore Gas Production /Fugitives: Open Ended Lines	<input type="checkbox"/>
FUGITIVES	2310021505	On-Shore Gas Production /Fugitives: Valves	<input type="checkbox"/>
FUGITIVES	2310021506	On-Shore Gas Production /Fugitives: Other	<input type="checkbox"/>
FUGITIVES	2310023511	On-Shore CBM Production /Fugitives: Connectors	<input type="checkbox"/>
FUGITIVES	2310023512	On-Shore CBM Production /Fugitives: Flanges	<input type="checkbox"/>
FUGITIVES	2310023513	On-Shore CBM Production /Fugitives: Open Ended Lines	<input type="checkbox"/>
FUGITIVES	2310023515	On-Shore CBM Production /Fugitives: Valves	<input type="checkbox"/>

When finished, press here

After making the selection(s), click this button.

5) **Step 5 – View/Edit County-Level Activity Data.** Click the “Step 5 – View/Edit County-Level Activity Data” tab to continue. In Step 5, the User can view and edit the activity data that EPA has compiled for the geographic area and source categories selected.

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page | Reset All Selections/Go to Step 1 | EXIT TOOL

Step 6 - View/Edit Basin Factors | Step 7 - View/Edit Emission Factors | Step 8 - Point Source Activity Adjustments | Step 9 - Point Source Emission Adjustments | Step 10 - Final Emissions  
 Step 1 - Select Geographic Level | Step 2 - Select Specific Geographic Location | Step 3 - Select Source Category Level | Step 4 - Select Specific Source Category | Step 5 - View/Edit County-Level Activity Data

Please click on the source category below to view/edit county-level activity data

Click here to review the Oil Production Data.

Click here to review the Natural Gas Production Data.

Click here to review the Coalbed Methane Production Data.

Click here to review the Produced Water Data.

Pick a type of production dataset

When finished, please continue to Step 6 to View/Edit Basin Factors

Once the county-level data set is selected, an Activity Data form will appear that the User can view or edit. To get to the next county, at the bottom of the screen is the record number. Use the triangle arrows to move through the counties.



## Nonpoint Oil and Gas Emissions Estimation Tool

Geographic and Source Selections × Activity Data: Natural Gas ×

### Natural Gas Production Activity Data

When finished, click here

State Abbreviation: AR

State and County FIPs Code: 05023

County Name: Cleburne

Basin Name: Arkoma Basin

Year: 2020

The User can filter for specific basins.

Filter for this Basin only Remove Basin Filter

If new values are entered, please enter a reference.

Import/Export Data...

Values from the 2017 Tool. Values here cannot be edited.

	Current Value	Current Value Reference	2017 Value	2017 Value Reference
County-Level Natural Gas Production (MSCF)	91,723,520.00	ENVERUS_2021	141,392,200.00	HPDI_2018
County-Level Condensate Production from natural gas wells (BBL)	0.00	ENVERUS_2021	0.00	HPDI_2018
County-Level Natural Gas Well Counts	1,078	ENVERUS_2021	1,073	HPDI_2018
Fraction of natural gas wells in the county needing compression	0.070	EPA_2021b	0.140	EPA_2019

When finished, click here

The User may also edit activity data in MS-Excel by using the “Import/Export Data...” button.

Geographic and Source Selections × Activity Data: Natural Gas ×

### Natural Gas Production Activity Data

State Abbreviation: AR

State and County FIPs Code: 05023

County Name: Cleburne

Basin Name: Arkoma Basin

Year: 2017

Filter for this Basin only Remove Basin Filter

Values here can be edited

Import/Export Data...

	Current Value	Current Value Reference	2014 Value	2014 Value Reference
County-Level Natural Gas Production (MSCF)	141,392,200.00	HPDI_2018	226,113,000.00	HPDI_2016
County-Level Condensate Production from natural gas wells (BBL)	0.00	HPDI_2018	0.00	HPDI_2016
County-Level Natural Gas Well Counts	1,073	HPDI_2018	889	HPDI_2016
Fraction of natural gas wells in the county needing compression	0.140	EPA_2019	0.085	CENSARA_STUDY_2012

When finished, click here

If the user elects to edit activity data in MS-Excel, after clicking the button, the data is then exported into MS-Excel as shown below.

## Nonpoint Oil and Gas Emissions Estimation Tool

A MS-Excel workbook will open when finished exporting. It is required that the User save this file to the hard drive for later upload. In the Excel file, the User can only edit the yellow shaded cells. When completed, simply save the file.

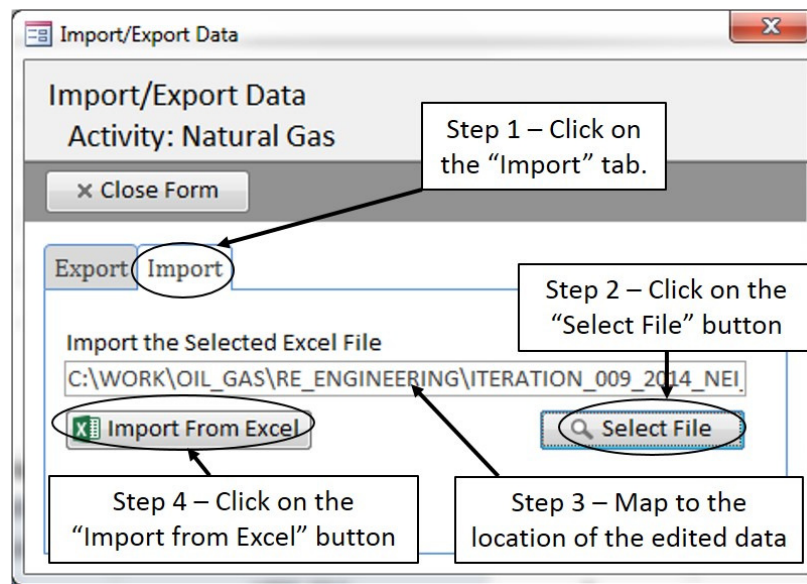
STATE_ABBR	STATE	COUNTY_FIPS	COUNTY_NAME	BASIN	YEAR	DATA_CATEGORY	PREVIOUS_VALUE	PREVIOUS_REFERENCE	CURRENT_VALUE	CURRENT_REFERENCE
AK	02013		Aleutians East	Not Assigned - SURVEY AVERAGE	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02013		Aleutians East	Not Assigned - SURVEY AVERAGE	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021
AK	02013		Aleutians East	Not Assigned - SURVEY AVERAGE	2020	County-Level Natural Gas Well Counts	0	HPDI_2018	0	ENVERUS_2021
AK	02013		Aleutians East	Not Assigned - SURVEY AVERAGE	2020	Fraction of natural gas wells in the county needing compression	7.562142E-02	EPA_2019	7.124434E-02	EPA_2021b
AK	02016		Aleutians West	Not Assigned - SURVEY AVERAGE	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02016		Aleutians West	Not Assigned - SURVEY AVERAGE	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021
AK	02016		Aleutians West	Not Assigned - SURVEY AVERAGE	2020	County-Level Natural Gas Well Counts	0	HPDI_2018	0	ENVERUS_2021
AK	02016		Aleutians West	Not Assigned - SURVEY AVERAGE	2020	Fraction of natural gas wells in the county needing compression	7.562142E-02	EPA_2019	7.124434E-02	EPA_2021b
AK	02020		Anchorage	AK Cook Inlet Basin	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02020		Anchorage	AK Cook Inlet Basin	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021
AK	02020		Anchorage	AK Cook Inlet Basin	2020	County-Level Natural Gas Well Counts	0	HPDI_2018	0	ENVERUS_2021
AK	02020		Anchorage	AK Cook Inlet Basin	2020	Fraction of natural gas wells in the county needing compression	0.2028985	EPA_2019	4.212963	EPA_2021b
AK	02050		Bethel	Yukon-Koyukuk Province	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02050		Bethel	Yukon-Koyukuk Province	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021
AK	02050		Bethel	Yukon-Koyukuk Province	2020	County-Level Natural Gas Well Counts	0	HPDI_2018	0	ENVERUS_2021
AK	02050		Bethel	Yukon-Koyukuk Province	2020	Fraction of natural gas wells in the county needing compression	0	EPA_2019	7.124434E-02	EPA_2021b
AK	02060		Bristol Bay	Bristol Bay Basin	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02060		Bristol Bay	Bristol Bay Basin	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021
AK	02060		Bristol Bay	Bristol Bay Basin	2020	County-Level Natural Gas Well Counts	0	HPDI_2018	0	ENVERUS_2021
AK	02060		Bristol Bay	Bristol Bay Basin	2020	Fraction of natural gas wells in the county needing compression	7.562142E-02	EPA_2019	7.124434E-02	EPA_2021b
AK	02068		Denali	Not Assigned - SURVEY AVERAGE	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02068		Denali	Not Assigned - SURVEY AVERAGE	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021
AK	02068		Denali	Not Assigned - SURVEY AVERAGE	2020	County-Level Natural Gas Well Counts	0	HPDI_2018	0	ENVERUS_2021
AK	02068		Denali	Not Assigned - SURVEY AVERAGE	2020	Fraction of natural gas wells in the county needing compression	7.562142E-02	EPA_2019	7.124434E-02	EPA_2021b
AK	02070		Dillingham	Yukon-Koyukuk Province	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02070		Dillingham	Yukon-Koyukuk Province	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021
AK	02070		Dillingham	Yukon-Koyukuk Province	2020	County-Level Natural Gas Well Counts	0	HPDI_2018	0	ENVERUS_2021
AK	02070		Dillingham	Yukon-Koyukuk Province	2020	Fraction of natural gas wells in the county needing compression	7.562142E-02	EPA_2019	7.124434E-02	EPA_2021b
AK	02090		Fairbanks North Star	Interior Lowlands Basin	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02090		Fairbanks North Star	Interior Lowlands Basin	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021
AK	02090		Fairbanks North Star	Interior Lowlands Basin	2020	County-Level Natural Gas Well Counts	0	HPDI_2018	0	ENVERUS_2021
AK	02090		Fairbanks North Star	Interior Lowlands Basin	2020	Fraction of natural gas wells in the county needing compression	7.562142E-02	EPA_2019	7.124434E-02	EPA_2021b
AK	02100		Haines	Not Assigned - SURVEY AVERAGE	2020	County-Level Natural Gas Production (MSCF)	0	HPDI_2018	0	ENVERUS_2021
AK	02100		Haines	Not Assigned - SURVEY AVERAGE	2020	County-Level Condensate Production from natural gas wells (BBL)	0	HPDI_2018	0	ENVERUS_2021

If data edits were made, then the User will need to go back to the Tool and click on the “Import/Export Data...” button to initiate importing the edited data file. After clicking, the Import/Export form will appear. The User will need to:

- Step 1 - Click on the “Import” tab
- Step 2 - Click the “Select File” button
- Step 3 – Map to the location of the edited data, and click “OK”
- Step 4 – Click on the “Import from Excel” button

## **Nonpoint Oil and Gas Emissions Estimation Tool**

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The edited data is now imported into the Tool.

## Nonpoint Oil and Gas Emissions Estimation Tool

6) Step 6 – View/Edit Basin Factors. Click the “Step 6 – View/Edit Basin Factors” tab to continue. In Step 6, the User can view and edit the basin factor data that EPA has compiled for the geographic area and source categories selected.

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

**Oil and Gas Production Sources**

Please click on the source category below to view/edit the basin factors.

Please click on the source category below to view/edit the gas composition factors.

**Step 6 – Pick a Source Category Basin Factor or Gas Composition dataset to view/edit**

Artificial Lifts	Dehydrators	Liquids Unloading	Associated Gas	Gas-Actuated Pumps
Associated Gas	Fugitives	Loading Operations	Condensate Tank	Liquids Unloading
CBM Dewatering Pumps	Gas-Actuated Pumps	Pneumatic Devices	Crude Oil Tank	Loading Operations
Condensate Tank	Heaters	Produced Water	Dehydrators	Pneumatic Devices
Crude Oil Tank	Lateral/Gathering Compressors	Wellhead Compressors	Fugitives	Produced Water

In the Basin Factors form, the User can view/edit the data. If the User updates values for one county in a basin, then all other counties in the basin and state can be updated by clicking on the “Click to apply these values to all other counties in the same basin for the state.” button.

Geographic and Source Selections   Basin Factors: Crude Oil Tanks

**Crude Oil Tanks Basin Factors Form**

State Abbreviation: AL  
State and County FIPs Code: 01001  
County Name: Autauga  
Basin Name: Mid-Gulf Coast Basin

The User can filter for specific basins.

Filter for this Basin only   Remove Basin Filter

When finished, click here

If new values are entered, please enter a reference.

Import/Export Data...

	Current Value	Current Value Reference	EPA Default Value	EPA Default Value Reference	2017 Value	2017 Value Reference
Crude Oil Fraction directed to Tanks	1	CENSARA_STUDY_2012_EXTENSION	1	CENSARA_STUDY_2012_AVERAGE	1	CENSARA_STUDY_2012_EXTENSION
Fraction of Oil Tanks with Flares	0.8103769	EPA_2021b	0.6234611	EPA_2019	0.	
Fraction of Oil Tanks with a VRU	0	EPA_2021b				
Average VOCs Loss (lb VOCs/BBL Crude Oil)	1.01541	CENSARA_STUDY_2012_EXTENSION		AVERAGE		
Flaring Capture Efficiency (%)	84	NOGC_Sep_2019		NOGC_Sep_2019		
Flaring Control Efficiency (%)	95	NOGC_Sep_2019	95	NOGC_Sep_2019	95	NOGC_Sep_2019
Gas Venting Rate (MCF gas/BBL Crude Oil)	0.0748	CENSARA_STUDY_2012_EXTENSION	0.0748	CENSARA_STUDY_2012_AVERAGE	0.0748	CENSARA_STUDY_2012_EXTENSION

EPA default values cannot be edited.

Values from the 2017 Tool. Values here cannot be edited.

When finished, click here

Similarly, the User can view/edit the gas composition data for select categories.



## Nonpoint Oil and Gas Emissions Estimation Tool

7) Step 7 – View/Edit Emission Factors. Click the “Step 7 – View/Edit Emission Factors” tab to continue. In Step 7, the User can view or edit the emission factors that are used to generate the emission estimates for the source categories selected.

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category   Step 4 - Select Emission Factor   Step 5 - Select Emission Factor   Step 6 - View/Edit Basin Factors   **Step 7 - View/Edit Emission Factors**   Step 8 - Point Source Activity Adjustment

Please select the emission factor source category you would like to view/edit.

**Oil and Gas Production Sources - Emission Factors**

Please click on a Source Category below to view/edit emission factors.

Artificial Lifts   Crude Oil Tanks   Lateral/Gathering Compressors  
Associated Gas   Dehydrators   Liquids Unloading  
CBM Dewatering Pump Engines   Fugitives   Wellhead Compressors  
Condensate Tanks   Heaters

**Note: there are no emission factors to review for Gas-Actuated Pumps, Loading Operations, Pneumatic Devices, and Produced Water**

Once a Source Category has been selected, the User can view or edit the emission factors. Remember to update the reference field (EMISSION\_FACTOR\_SOURCE) for any updated emission factors.

**WELLHEAD COMPRESSORS EMISSION FACTORS FORM**

ST/	BASIN	ATTAINMENT	SOURCE_CATEGORY	SCC	SCC_SHORTENED	POLLUTANT_DESCRIPTION	POLLUTANT	EMISSION_FACTOR	EMISSION_FACTOR_SOURCE	EMISSION_FACTOR_UNITS	EMISSION_FACTOR_COMMENT
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Polycyclic Aromatic Hydrocarbons	250	4.662483E-04	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Benzene	78875	1.618409E-04	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	1,2,4-Trichlorobenzene	100425	1.988539E-04	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Sulfur Dioxide	75014	2.133687E-03	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	1,2,2-Trichloroethane	79345	2.405841E-04	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Toluene	108883	3.494457E-03	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Trichloroethane, 1,1,2-	79065	3.069897E-03	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Trimethylpentane, 2,2,4-	540841	3.494457E-03	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Vinyl chloride	75014	8.962939E-05	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Volatile Organic Compound	VOC	0.4354464	G	HP-HR	EPA_2013
AR	Illinois Basin	ATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Xylenes (Mixed Isomers)	1330207	9.72497E-04	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Acetaldehyde	75070	2.815887E-02	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Acrolein	107028	2.823144E-02	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Benzene	71432	7.039717E-03	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Biphenyl	92524	1.433344E-05	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Butadiene, 1,3-	106990	2.97555E-03	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Carbon Dioxide	CO2	399.1592	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Carbon Monoxide	CO	1.280938	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Carbon tetrachloride	56235	2.202633E-04	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Chlorobenzene	108907	1.611153E-04	G	HP-HR	EPA_2013
AR	Illinois Basin	NONATTAINMENT	WELLHEAD COMPRESSORS	2310021102	On-Shore Gas Productive	Chloroform	57557	1.36537E-04	G	HP-HR	EPA_2013

These emission factors can be edited. If changes are made, please update the reference.

Emission Factors are presented at the state, basin, and attainment status level.

When finished, click here

## Nonpoint Oil and Gas Emissions Estimation Tool

8) **Step 8 – Point Source Activity Adjustments.** Click the “Step 8 – Point Source Activity Adjustments” tab to continue. After the activity data, basin factors, and emission factors have been reviewed and/or updated, the User may enter point source activity adjustments to account for emissions that are to be reported to the point sources emissions inventory. If the User does not have any point source activity adjustments, then they will need to click the “When finished, click here to complete this step.” button. A message box will appear instructing the User to proceed to Step 9.

The screenshot shows the 'Production Sources - Point Source Activity Adjustments' form. It features two identical grids of source categories. The first grid is titled 'Please click on a Source Category below to view/edit activity data for point sources adjustments.' and the second is titled 'If you created point source activity data adjustments and saved them for later use, please click on a Source Category below to populate'. Both grids list 15 categories: Artificial Lifts, Associated Gas, CBM Dewatering Pump Engines, Condensate Tanks, Crude Oil Tanks, Dehydrators, Fugitives, Gas-Actuated Pumps, Heaters, Lateral/Gathering Compressors, Liquids Unloading, Loading Operations, Pneumatic Devices, Produced Water, and Wellhead Compressors. Annotations include: 'Select a Source Category to make point source activity adjustments' pointing to the first grid; 'When finished, click here to complete this step.' pointing to a button on the right; 'When finished, click here to proceed to Step 9.' pointing to another button; 'Users can refer to this point/nonpoint crosswalk' pointing to a 'Nonpoint Source SCCs and Point Source SCCs Crosswalk' link; and 'Select a Source Category to apply saved point source activity adjustments' pointing to the second grid. A 'Clear all point source activity holding tables' button is at the bottom.

Currently, ALL point source activity adjustments (e.g. county-level point source well counts, county-level point source barrels of oil produced, etc.) are defaulted to zero (i.e., no point source activity adjustments).

The screenshot shows the 'HEATERS POINT SOURCE ACTIVITY ADJUSTMENT FORM'. It includes input fields for 'State abbreviation' (AR), 'State and County FIPs Code' (05023), 'County' (Clebume), and 'Year' (2020). Below these is a table titled 'Point Source Well Counts' with columns for 'Oil Wells', 'Gas Wells', and 'CBM Wells', all showing a value of 0. Annotations include: 'Enter the point sources activity data' pointing to the table; 'When finished, click here' pointing to a button on the right; and 'When finished, click here' pointing to another button at the bottom right.

	Oil Wells	Gas Wells	CBM Wells
Point Source Well Counts	0	0	0

## Nonpoint Oil and Gas Emissions Estimation Tool

It is encouraged that point source activity adjustments have priority over point source emission adjustments. Additionally, Users should pay careful attention to ensure that the point source activity data is entered in the same units as the nonpoint activity data. Users should refer to the “Nonpoint Source SCCs and Point Source SCCs Crosswalk” button to identify point source SCCs. After any point source activity adjustments have been made, proceed to Step 9.

9) Step 9 – Point Source Emission Adjustments. Click the “Step 9 – Point Source Emission Adjustments” tab to continue. In Step 9, the User can make point source emission adjustments directly in the emission tables. Select a Source Category to open. If a User has no point source emissions adjustments, they may click on the “When finished, click here to complete this step” button.

Select a Source Category to make point source emissions adjustments

When finished, click here to proceed to Step 10.

When finished, click here to complete this step.

Select a Source Category to apply saved point source emissions adjustments

Production Sources - Point Source Emission Adjustments

Please click on a Source Category below to view/edit calculated emission records for point sources adjustments.

Artificial Lifts	Dehydrators	Liquids Unloading
Associated Gas	Fugitives	Loading Operations
CBM Dewatering Pump Engines	Gas-Actuated Pumps	Pneumatic Devices
Condensate Tanks	Heaters	Produced Water
Crude Oil Tanks	Lateral/Gathering Compressors	Wellhead Compressors

If you created point source emissions data adjustments and saved them for later use, please click on a Source Category below to populate

Artificial Lifts	Dehydrators	Liquids Unloading
Associated Gas	Fugitives	Loading Operations
CBM Dewatering Pump Engines	Gas-Actuated Pumps	Pneumatic Devices
Condensate Tanks	Heaters	Produced Water
Crude Oil Tanks	Lateral/Gathering Compressors	Wellhead Compressors

Clear all point source emissions holding tables

Point source emission estimates are to be entered in the “POINT\_EMISSIONS\_TPY” field. **It is important to note that if point source activity adjustments were made in Step 8, then point source emission adjustments should NOT be made in these tables for overlapping SCCs. Also, point source emission adjustments need to be entered as tons per year (TPY).**



## Nonpoint Oil and Gas Emissions Estimation Tool

**WELLHEAD COMPRESSORS POINT SOURCE EMISSIONS ADJUSTMENT FORM**

When finished, click here to finalize emissions.

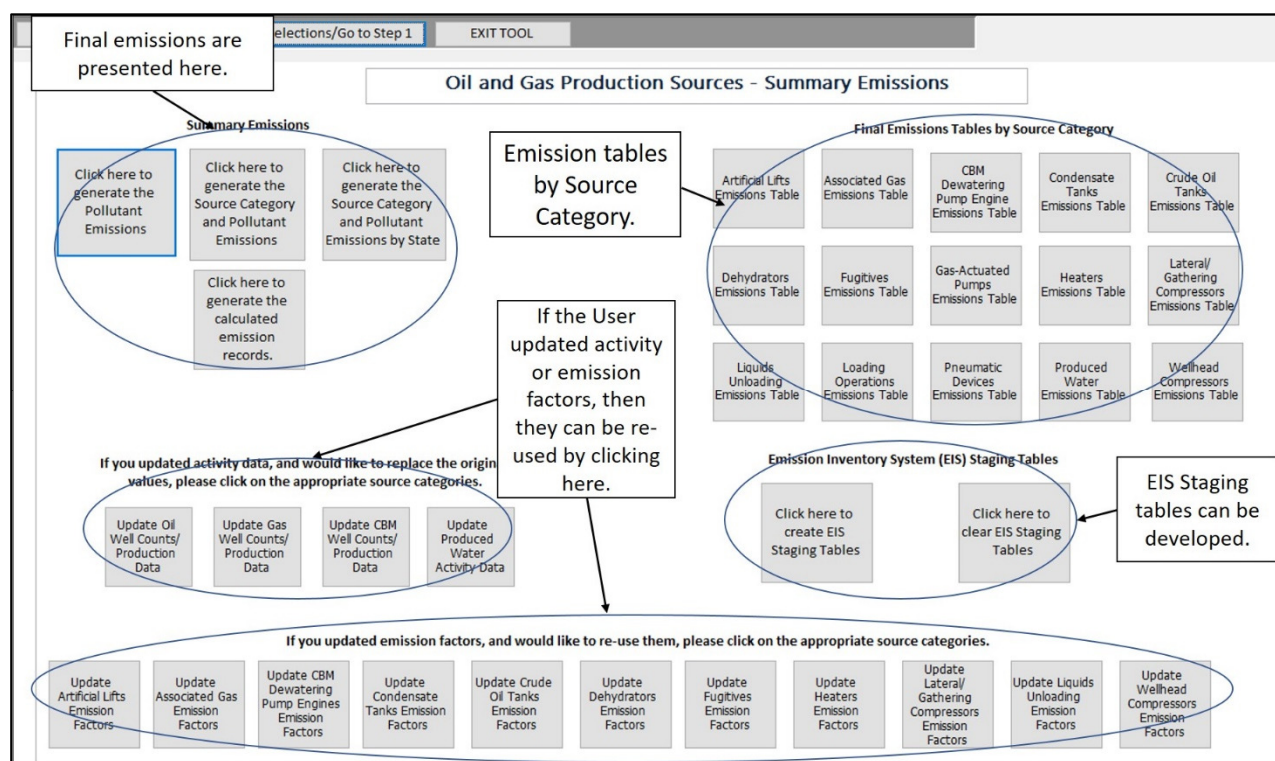
When finished, click here.

Users can enter point source emissions adjustments.

STATE	STATE_A	COUNTY_NA	SCC	SOURCE_CATEGORY	POLLUTANT	TPY	POINT_EMISSIONS_TPY
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	75003 Ethyl Chloride	825E-04	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	75014 Vinyl Chloride	205E-03	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	75070 Acetaldehyde	1.3091	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	75092 Methylene Chloride	3.131818E-03	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	75343 Ethyldiene Dichloride	3.695546E-03	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	78875 Propylene Dichloride	4.212296E-03	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	79005 1,1,2-Trichloroethane	4.979591E-03	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	79345 1,1,2,2-Tetrachloroethane	6.263637E-03	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	91203 Naphthalene	1.165036E-02	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	92524 Biphenyl	3.319727E-02	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	CH4 Methane	253.4544	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	CO Carbon Monoxide	76.93658	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	CO2 Carbon Dioxide	22303.99	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES		4.246591E-02	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES		171.7407	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES		1.563307E-02	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES		2.02502	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES		1.563307E-02	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES		2.02502	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	PM-CON PM Condensable	2.009387	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	SO2 Sulfur Dioxide	0.1192249	0
05023	AR	Cleburne	2310021202	WELLHEAD COMPRESSOR ENGINES	VOC Volatile Organic Compounds	18.46957	0
05023	AR	Cleburne	2310021302	WELLHEAD COMPRESSOR ENGINES	100414 Ethyl Benzene	1.946151E-03	0
05023	AR	Cleburne	2310021302	WELLHEAD COMPRESSOR ENGINES	100425 Styrene	9.338181E-04	0
05023	AR	Cleburne	2310021302	WELLHEAD COMPRESSOR ENGINES	106934 Ethylene Dibromide	1.671456E-03	0
05023	AR	Cleburne	2310021302	WELLHEAD COMPRESSOR ENGINES	106990 1,3-Butadiene	5.202699E-02	0
05023	AR	Cleburne	2310021302	WELLHEAD COMPRESSOR ENGINES	107028 Acrolein	0.2063816	0
05023	AR	Cleburne	2310021302	WELLHEAD COMPRESSOR ENGINES	108883 Toluene	4.378839E-02	0
05023	AR	Cleburne	2310021302	WELLHEAD COMPRESSOR ENGINES	108907 Chlorobenzene	1.01229E-03	0
05023	AR	Cleburne	2310021302	WELLHEAD COMPRESSOR ENGINES	1330207 Xylenes (Mixed Isomers)	0.0153024	0

After point source emission adjustments are made (if applicable), then the User should proceed to Step 10.

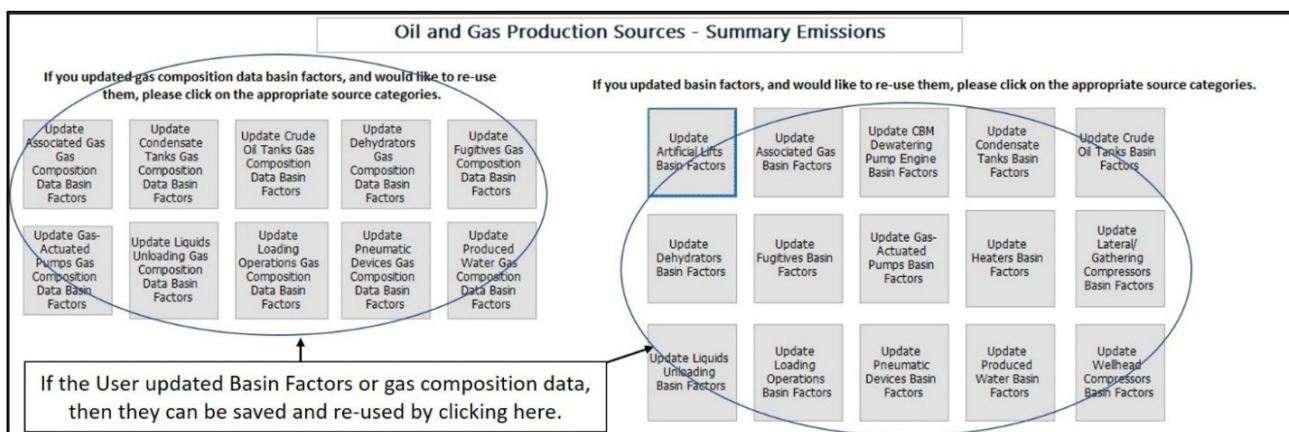
10) **Step 10 – Final Emissions.** Click the “Step 10 – Final Emissions” tab to continue. In Step 10, the User can review the final emissions; update county-level activity data, emission factors, and/or basin factors they provided in Steps 5 through 7; or generate the Emission Inventory System (EIS) data tables.



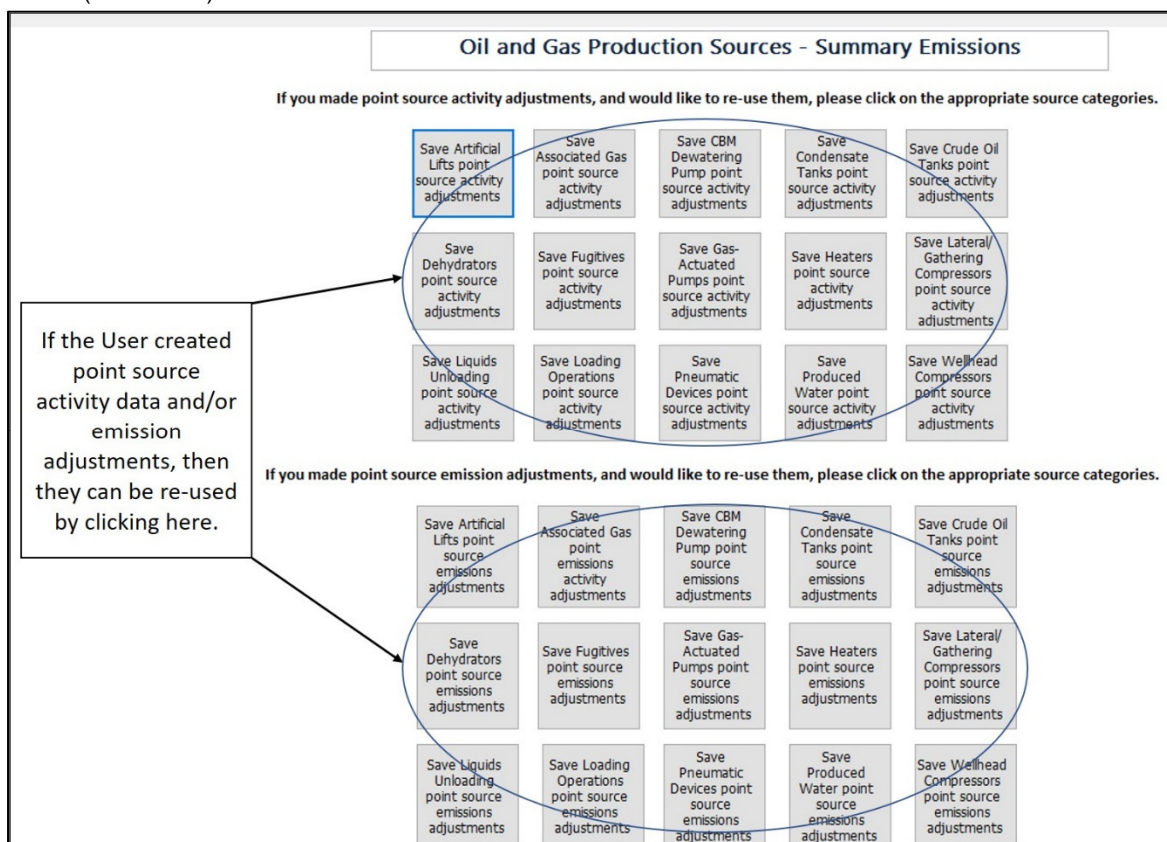
Summary screen (continued)



## Nonpoint Oil and Gas Emissions Estimation Tool



Summary screen (continued)



Additional notes:

- 1) In the EIS Staging Tables, the ControlApproach, ControlMeasure, ControlPollutant, Emissions, EmissionsProcess, Location, and ReportingPeriod are populated.
- 2) EPA's EIS area\_bridgetool (included in the .zip file) can be used to generate the .xml file needed for EIS upload.
- 3) If the User wishes to reset the tool, and regenerate the emissions, the following steps are recommended:
  - a. Click on the "Reset All Selections/Go to Step 1" button at the top of the Dashboard.

## Nonpoint Oil and Gas Emissions Estimation Tool

- b. Compact and Repair the database.

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

To exit the Tool, click here.

To return to the Home page, click here.

To reset the Tool, click here.

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category Level   Step 4 - Select Specific Source Category   Step 5 - View/Edit County-Level Activity Data   Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Basin Emissions   Step 8 - Point Source Activity Adjustments   Step 9 - Point Source Emission Adjustments   Step 10 - Final Emissions

Oil and Gas Production Sources - Summary Emissions

**Summary Emissions**

Click here to generate the Pollutant Emissions

Click here to generate the Source Category and Pollutant Emissions

Click here to generate the Source Category and Pollutant Emissions by State

Click here to generate the calculated emission records.

**Final Emissions Tables by Source Category**

Artificial Lifts Emissions Table	Associated Gas Emissions Table	CBM Dewatering Pump Engine Emissions Table	Condensate Tanks Emissions Table	Crude Oil Tanks Emissions Table
Dehydrators Emissions Table	Fugitives Emissions Table	Gas-Actuated Pumps Emissions Table	Heaters Emissions Table	Lateral/Gathering Compressors Emissions Table
Liquids Unloading Emissions Table	Loading Operations Emissions Table	Pneumatic Devices Emissions Table	Produced Water Emissions Table	Wellhead Compressors Emissions Table

- 4) References cited for the original data in the Tool are found in the "Master References" tab.

**Oil and Gas Tool: Production Activities - Dashboard View**

Back to Home Page   Reset All Selections/Go to Step 1   EXIT TOOL

Step 1 - Select Geographic Level   Step 2 - Select Specific Geographic Location   Step 3 - Select Source Category Level   Step 4 - Select Specific Source Category   Step 5 - View/Edit County-Level Activity Data   Step 6 - View/Edit Basin Factors   Step 7 - View/Edit Basin Emissions   Step 8 - Point Source Activity Adjustments   Step 9 - Point Source Emission Adjustments   Step 10 - Final Emissions   Master References

References are compiled into a single table. The references cited in the Tool for the original data are here.

FIELD_REFERENCE	FIELD_REFERENCE_DESCRIPTION
2019_IL_CF_2020_EIA	Illinois production data from 2019 carried forward and adjusted by the 2020 to 2019 EIA state totals
2019_INOGC_ADJ_2020	Indiana production data from 2019 carried forward and adjusted by the 2020 to 2019 EIA state totals
2019_KY_EIA_2020	Kentucky production data from 2019 carried forward and adjusted by the 2020 to 2019 EIA state totals
ADEC_2016	Alaska Department of Environmental Conservation. Personal communication to Mr. Mike Pring/ERG from
ADEC_2019	Personal communication from Molly Birnbaum, ADEC to Jennifer Snyder, EPA. September 19, 2019.
API_2009a	API Compendium (8/2009), Table 4-5
API_2009b	API Compendium (8/2009), Table 4-11
AZDEQ_2019	Arizona Department of Environmental Quality. 2017 Production Reports received on 2/27/2019 via FTP
BOEM_2014	Bureau of Ocean Energy Management, Speciation data for North Slope, AK.
CALC_PW_TX_PROD	Produced water factor calculated from 2020 Texas wells reporting produced water, and applied to missing wells.
CALC_VEIL_RATIO	Produced water production factors calculated from the Veil Report
CALC_WTR_LA_PROD	Produced water factor calculated from 2018 Louisiana wells reporting produced water, and applied to missing wells.
CARB_2021	Basin factor updates for select source categories
CENRAP_2008	ENVIRON. Recommendations for Improvements to the CENRAP STATES' OIL AND GAS EMISSIONS INVENTORIES. November 2008

Record: 1 of 126   No Filter   Search

**APPENDIX C – US OIL AND GAS BASINS (FOUND IN THE “NATIONAL OIL AND GAS TOOL  
REPORT APPENDIX C - DATA ELEMENT DICTIONARY.XLSX” FILE)**

**APPENDIX D – DATA ELEMENT DICTIONARY (FOUND IN THE “NATIONAL OIL AND GAS TOOL  
REPORT APPENDIX D – US OIL AND GAS BASINS.XLSX” FILE)**