Oil and Gas 101: An Overview of Oil and Gas Upstream Activities and Using EPA’s Nonpoint Oil and Gas Emission Estimation Tool for the 2014 NEI

Jennifer Snyder, U.S. EPA
Regi Oommen and Mike Pring, Eastern Research Group
April 14, 2015
2015 Emission Inventory Conference
San Diego, CA
Presenters

- Mike Pring, Eastern Research Group
  - mike.pring@erg.com
- Jennifer Snyder, U.S. EPA
  - Snyder.Jennifer@epa.gov
- Regi Oommen, Eastern Research Group
  - regi.oommen@erg.com
Training Overview

• Oil and gas production in the United States
• Upstream oil and gas emission sources
• Estimating emissions from upstream sources
• Oil and gas emission estimates in the NEI
• Future plans
• Use and application of the Nonpoint Oil and Gas Emission Estimation Tool
Oil and Gas Production in the US

- Over 3 billion barrels of crude oil produced in 2014
  - ~50% increase since 2009
  - ~17% of production offshore (was 30% in 2010)
  - Texas, North Dakota, California
- Over 27 trillion cubic feet of gas produced in 2014
  - ~25% increase since 2009
  - ~5% of production offshore
  - Texas, Pennsylvania, Louisiana
US Onshore Crude Oil Production

2009 Oil Production (1,360,062 MBBL)
- Texas: 371,886
- North Dakota: 66,637
- California: 235,491
- Alaska: 206,975
- Oklahoma: 79,728
- All Other States: 399,344

2014 Oil Production (2,640,427 MBBL)
- Texas: 1,153,811
- North Dakota: 396,749
- California: 181,425
- Alaska: 127,729
- Oklahoma: 203,359
- All Other States: 577,354

Source: U.S. Energy Information Administration
US Onshore Natural Gas Production

2009 Onshore Gas Production (19,219,018 MMCF)

2013 Onshore Gas Production (24,381,632 MMCF)

Source: U.S. Energy Information Administration
Natural Gas, NGLs, Condensate, Oil

• Natural Gas (C1 – primarily Methane)
• Natural Gas Liquids (C2 – C4)
  • Ethane, Propane, Butane
  • Extracted at gas processing plants
  • “Wet gas”
• Condensate (~C5+)
  • Condenses out of gas stream at surface
• Crude Oil (mixture of heavier hydrocarbons)
  • Distilled into gasoline, kerosene, diesel, jet fuel
Eagle Ford Shale

Source: U.S. Energy Information Administration
Upstream Oil and Gas Emission Sources

- **Production & Processing**
  1. Drilling and Well Completion
  2. Producing Wells
  3. Gathering Lines
  4. Gathering and Boosting Stations
  5. Gas Processing Plant

- **Natural Gas**
  6. Transmission Compressor Stations
  7. Transmission Pipeline
  8. Underground Storage

- **Distribution**
  9. Distribution Mains
  10. Regulators and Meters for:
      a. City Gate
      b. Large Volume Customers
      c. Residential Customers
      d. Commercial Customer

*Source: Adapted from American Gas Association and EPA Natural Gas STAR Program*
Upstream Oil and Gas Emission Sources

**Exploration Sources**
- Drilling Rigs
- Hydraulic Fracturing Pumps
- Mud Degassing
- Well Completion Venting

**Production Sources (continued)**
- Fugitive Leaks
- Gas-Actuated Pneumatic Pumps
- Heaters
- Lateral Compressor Engines
- Liquids Unloading
- Hydrocarbon Liquids Loading
- Mud Degassing
- Pneumatic Devices
- Produced Water Tanks
- Wellhead Compressor Engines

**Production Sources**
- Artificial Lift Engines
- Associated Gas Venting
- Condensate Tanks
- Crude Oil Tanks
- Dehydrators
Tool Estimation Methodologies

• Area (nonpoint) source methodologies
• Based on point source methodologies averaged over the population
• Scaled to the county level using activity factors (well counts, oil production, gas production)
• Refer to “2011 Nonpoint Oil and Gas Emission Estimation Tool” (November, 2014) for details
Drilling Rigs

- Used to drill wellbore to target formation
- 2 primary rig types
  - Mechanical
  - Diesel-electric
- Powered by large, diesel engines (~1,000 – 1,500 HP)
- ~2 – 4 weeks
Drilling Rigs

- Emissions based on cumulative feet drilled
- Process characteristics needed to estimate emissions
  - Engine size and type (HP)
  - Operating hours (hr/spud)
- Emission factors from EPA's NONROAD model
- Methodology accounts for different types of rig configurations (mechanical and diesel/electric)
Mud Degassing

- Mud degassing refers to the process of “off-gassing” of entrained gas in the drilling mud once it is outside of the wellbore.
- Drilling mud used to keep the drill bit cool, carry out drill cuttings, and maintain wellbore pressure to prevent formation fluids from entering wellbore.
- Emissions based on total drilling days.
- Emission factor derived from 1977 EPA report “Atmospheric Emissions from Offshore Oil and Gas Development and Production.”
Hydraulic Fracturing Pumps
Hydraulic Fracturing Pumps

- Emissions based on number of fracture events
- Process characteristics needed to estimate emissions
  - Engine size (HP)
  - Number of engines
  - Operating hours (hr/event)
- Emission factors from EPA's NONROAD model
Well Completion Venting

• Emissions generated as gas is vented before well brought into production
• For fractured wells, emissions are generated as gas entrained in the flowback fluid is emitted through open vents at the top of flowback tanks
• Fractured gas wells regulated under NSPS OOOO
Well Completion Venting

• Emissions based on number of completion events
• Process characteristics needed to estimate emissions
  • Volume of gas released per completion (MCF/event)
    • Oil and gas
    • Conventional and unconventional
• Gas composition
• Controls
Production Sources

Source: Texas Commission on Environmental Quality Air Permit Reference Guide APDG 5942
Artificial Lift Engines

- “Pumpjack” engines
- Engines used to lift oil out of the well if there is not enough bottom hole pressure for the oil to flow to the surface
- Generally use casinghead gas
Artificial Lift Engines

- Emissions based on number of oil wells
- Process characteristics needed to estimate emissions
  - Engine size (HP)
  - Engine operating schedule (hr/yr)
  - Fraction of oil wells with engines
- Emission factors from AP-42
- Electric engines are common, accounted for in methodology
Associated Gas Venting

- Refers to the practice of venting gas produced at oil wells where the well is not connected to a gas sales pipeline
- May be flared (e.g. Bakken Shale)
- Process characteristics needed to estimate emissions
  - Quantity of gas vented per barrel of oil production (MCF/bbl)
  - Fraction of gas flared
  - Composition of the vented gas
Condensate Tanks
Condensate Tanks

- Emissions based on condensate production
- Emissions occur from flashing, working, and breathing losses
- Flashing losses are generally the largest component and occur when gases entrained in a liquid “flash off” as the pressure drops
- Emissions per barrel of condensate needed to estimate total county-level emissions (lb/bbl)
- Regulated under NSPS OOOO
Crude Oil Tanks

- Used to store crude oil at a well pad or central tank battery prior to transfer to a refinery
- Some oil fields pipe oil directly downstream and do not have tanks in the field
  - Accounted for in Tool
- Largest VOC source as calculated by the Tool
Crude Oil Tanks

- Emissions based on oil production
- Emissions occur from flashing, working, and breathing losses
- Emissions per barrel of crude oil needed to estimate total county-level emissions (lb/bbl)
- Regulated under NSPS OOOO
Dehydrators

• Use glycol to remove water from gas stream to prevent corrosion or freezing issues downstream
• Small reboiler used to regenerate the glycol
• May be located at wellpad, or at centrally located gathering station
Dehydrators

- Emissions generated from the still vent and the reboiler
- Emissions from the still vent based on gas production
  - Emissions per throughput (lb/MMSCF)
- Emissions from the reboiler based on gas well count
  - Number of dehydrators per well
  - Reboiler size (MMBtu/hr) and operating schedule (hr/yr)
- NESHAP HH may require controls
Fugitive Leaks

- Emissions of gas that escape through well site components such as connectors, flanges, and valves
- Source category only covers components located at the well pad
Fugitive Leaks

- Emissions based on well count
- Process characteristics needed to estimate emissions
  - Counts of fugitive components by type per well
  - Operating schedule (hr/yr)
  - Composition of leaked gas
Gas-Actuated Pneumatic Pumps

- Small gas-driven plunger pumps used to provide a constant supply of chemicals or lubricants
- Commonly used in sites where electric power is unavailable
- Gas-actuated pumps vent by design
Gas-Actuated Pneumatic Pumps

- Emissions based on well counts
- Kimray pumps
- Chemical injection pumps (CIP)
- Process characteristics needed to estimate emissions
  - Count of pumps per well (oil, gas, CBM)
  - Pump vent rate (SCF per throughput or day)
  - Composition of vented gas
Heaters

- Line heaters - used to maintain temperatures as pressure decreases to prevent formation of hydrates (Marcellus Shale)
- Heater treaters – used to heat oil/water emulsions to aid in separation (Bakken Shale, Permian Basin)
Heaters

- Emissions based on the number of wells
- Process characteristics needed to estimate emissions
  - Number of heaters per well
  - Heater size (MMBtu/hr)
  - Operating schedule (hr/yr)
  - \( \text{H}_2\text{S} \) content (to estimate \( \text{SO}_2 \))
Lateral Compressor Engines

- Large “line” engines
- May serve ~10 to 100 wells
- Used at gathering or booster stations (mid-stream)
- Natural gas-fired
- Rich-burn or lean-burn
Lateral Compressor Engines

- Emissions based on the number of gas wells
- Process characteristics needed to estimate emissions
  - Number of gas wells served by a lateral engine
  - Engine size (HP)
  - Operating schedule (hr/yr)
  - Control information
Liquids Unloading

- Used to remove accumulation of fluids in the wellbore
- Also known as “well blowdowns”
- May be controlled (flaring or plunger lifts)
Liquids Unloading

• Emissions based on the number of gas wells
• Process characteristics needed to estimate emissions
  • Number of unloading events per well
  • Volume of vented gas per liquids unloading event (MCF/event)
  • Composition of vented gas
  • Control information
Hydrocarbon Liquids Loading

• Emissions generated during transfer of liquids from tanks to trucks
• As with storage tank emissions, where liquids are piped directly downstream, no emissions from this category
  • Accounted for in Tool
Hydrocarbon Liquids Loading

- Emissions based on oil and condensate production
- AP-42 loading loss equation used to estimate emissions
- Tank vapor composition needed to estimate VOC and HAP emissions

\[ L = 12.46 \times \left( \frac{S \times V \times MW_{gas}}{T} \right) \]
Pneumatic Devices

• Use high-pressure gas to produce mechanical motion (levers, switches)
• Largest CH$_4$ source under Subpart W and in the GHG EI (production sector)
• 2$^{nd}$ largest VOC source as calculated by the Tool
Pneumatic Devices

- Emissions based on the number of wells
- Process characteristics needed to estimate emissions
  - Number of devices per well
  - Type of devices (high, low, and intermittent-bleed)
  - Volume of vented gas per device (SCF/hr/device)
  - Operating schedule (hr/yr)
  - Composition of vented gas
- Regulated under NSPS OOOO
Produced Water Tanks

- Store water separated at the wellhead
- Emissions generated from working and breathing losses
- Water may be injected underground to maintain pressure (waterflooding) or for disposal
Produced Water Tanks

- Emissions based on produced water production
- Emissions occur from working and breathing losses
- Process characteristics needed to estimate emissions
  - Emissions per barrel of production (lb/bbl)
  - Fraction of produced water directed to tanks
  - Composition of the tank vapors
Wellhead Compressor Engines

- Provide energy to move produced gas downstream to gathering or boosting station
- Brought onsite as well pressure drops
- Utilize produced gas as fuel
- Largest NO$_x$ source as calculated by the Tool
Wellhead Compressor Engines

- Emissions based on the number of gas wells
- Process characteristics needed to estimate emissions
  - Fraction of gas wells requiring compression
  - Engine size (HP)
  - Operating schedule (hr/yr)
  - Control information