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

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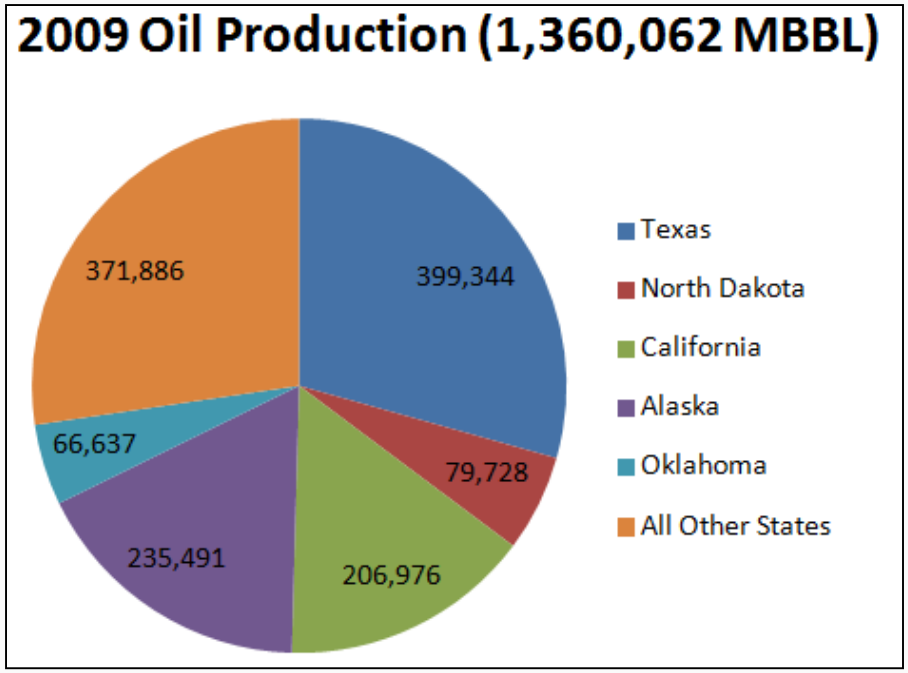
Training Overview

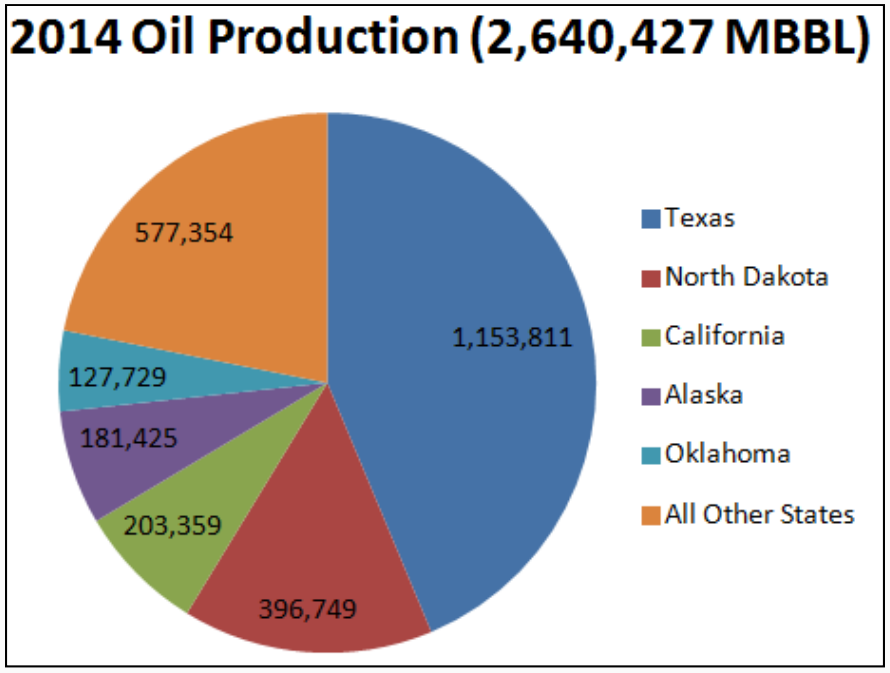
- Oil and gas production in the United States
- Upstream oil and gas emission sources
- Estimating emissions from upstream sources
- Oil and gas emission estimates in the NEI
- Future plans
- Use and application of the Nonpoint Oil and Gas Emission Estimation Tool

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

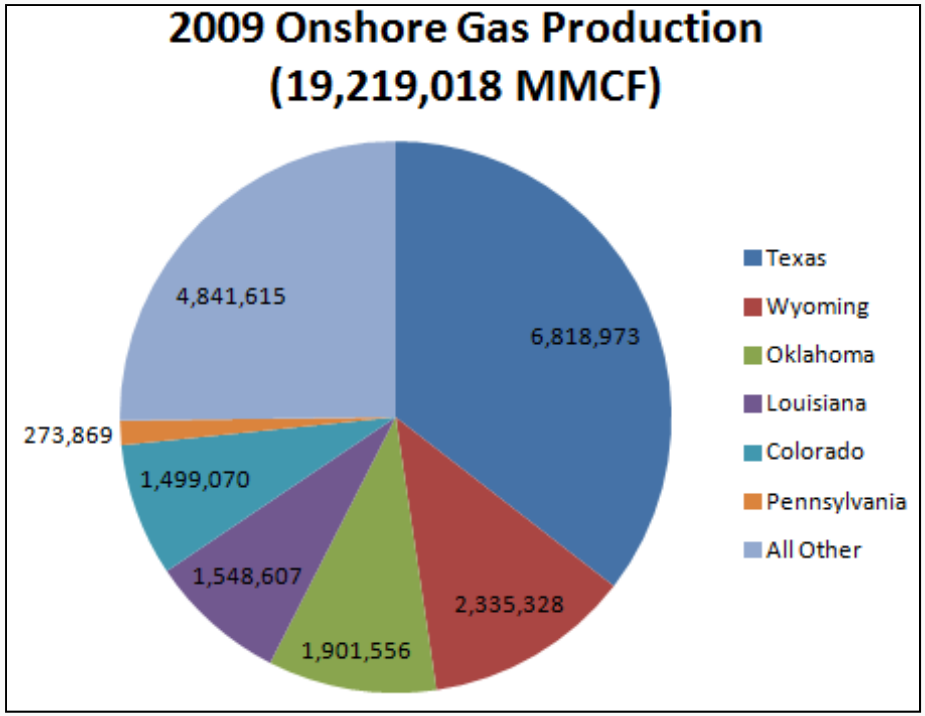
US Onshore Crude Oil Production

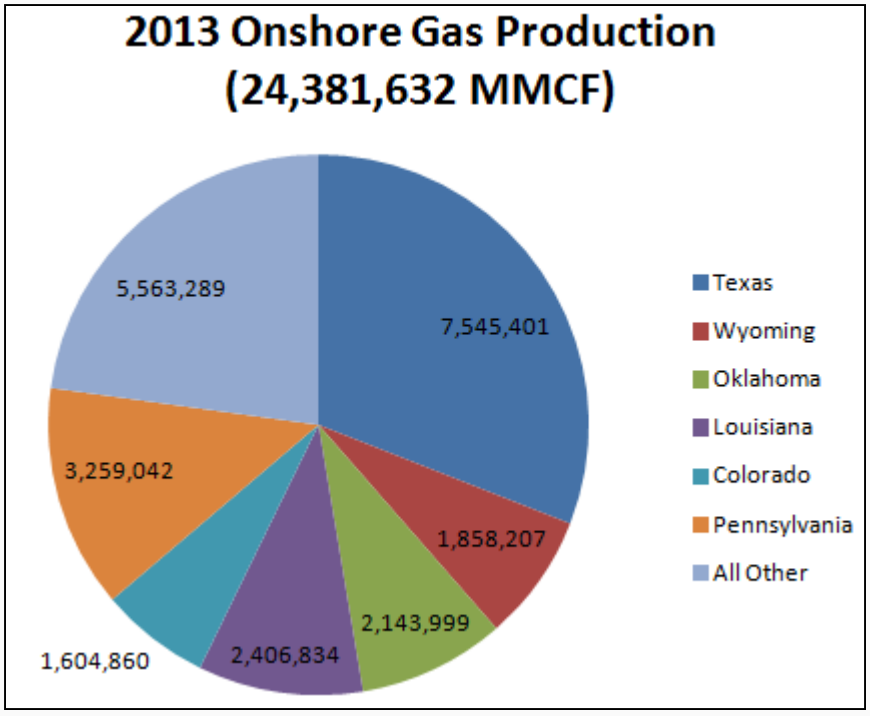




Source: U.S. Energy Information Administration

US Onshore Natural Gas Production



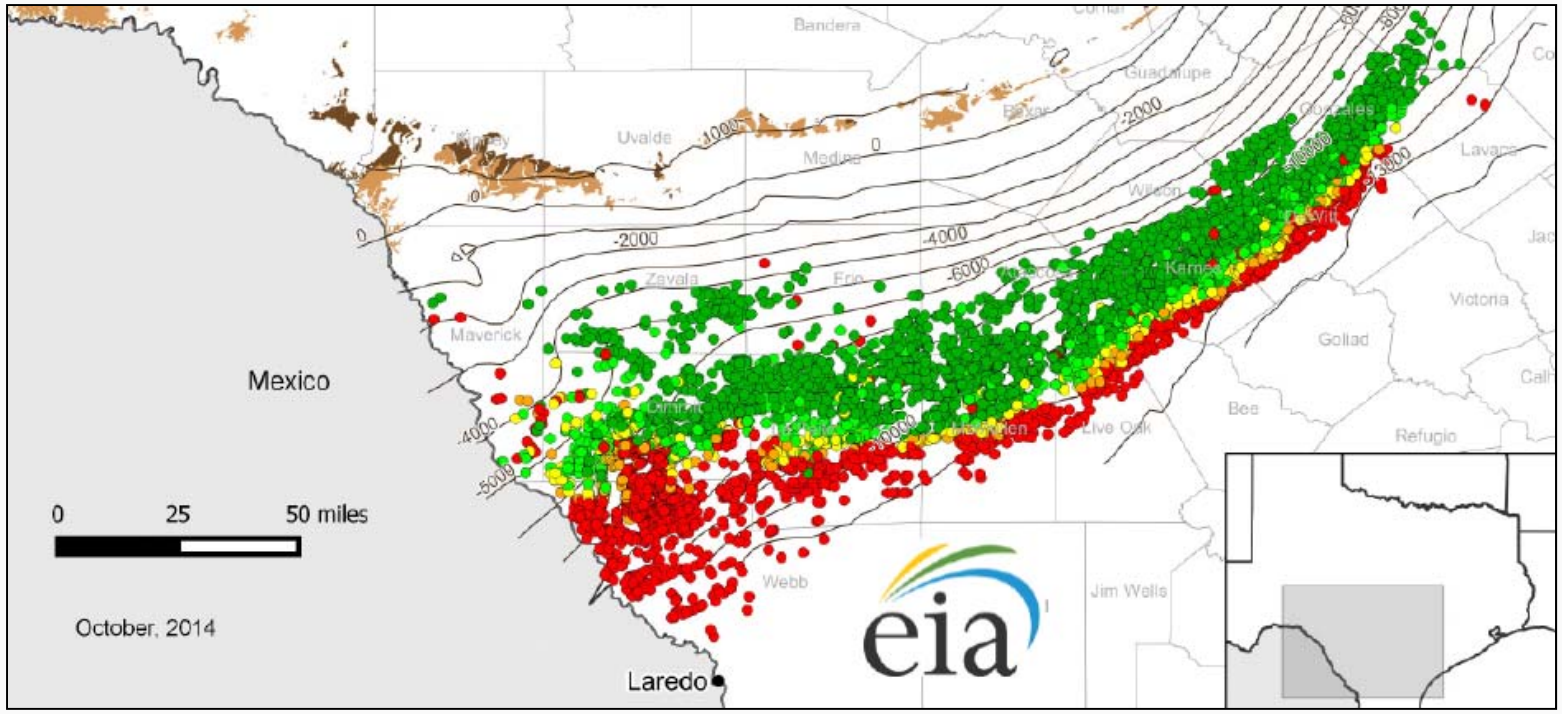


Source: U.S. Energy Information Administration

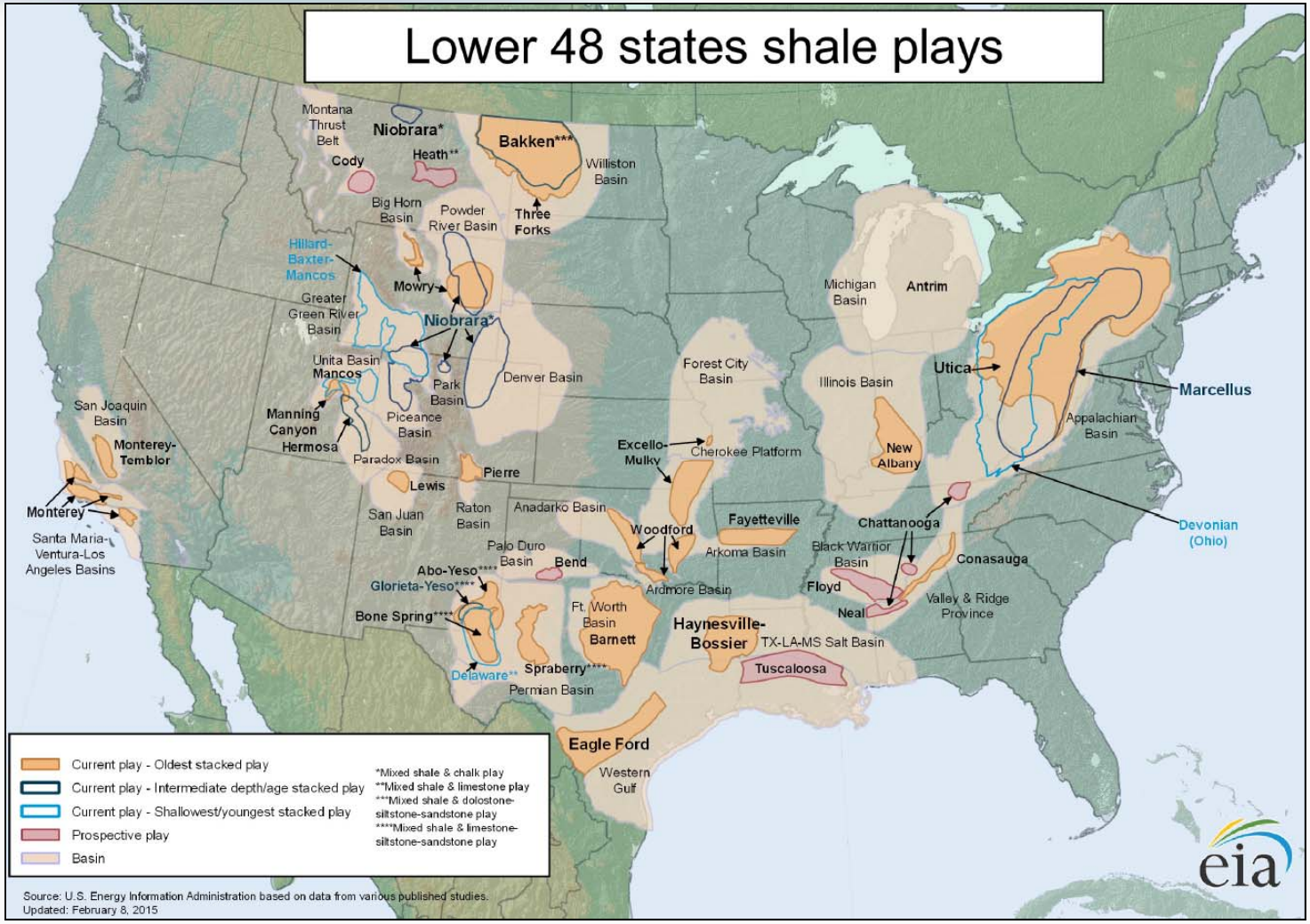
Natural Gas, NGLs, Condensate, Oil

- 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

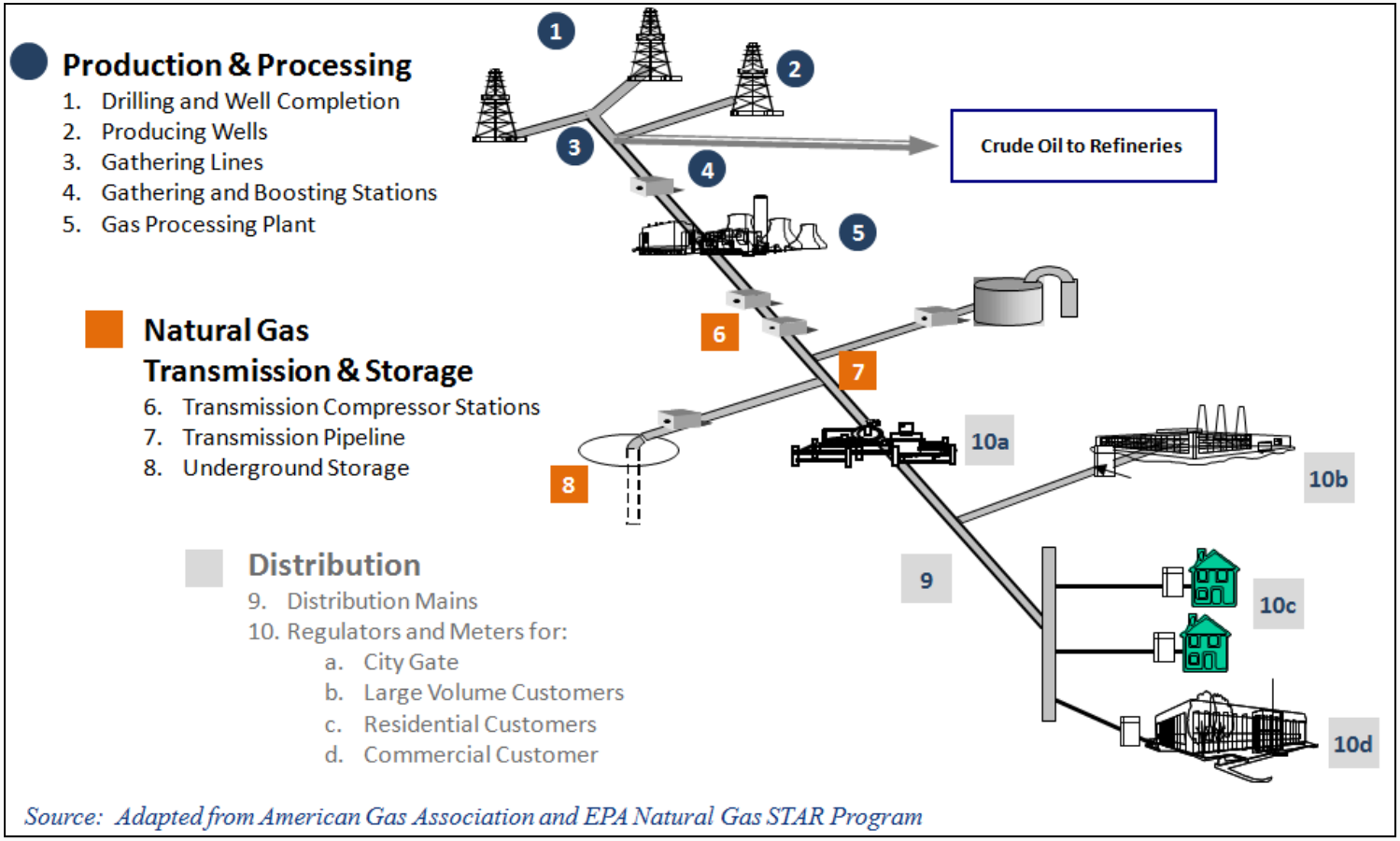
Eagle Ford Shale



Source: U.S. Energy Information Administration


Lower 48 states shale plays
Montana Thrust Belt
Niobrara*
Heath**
Cody
Bakken***
Williston Basin
Big Horn Basin
Powder River Basin
Three Forks
Hilliard-Baxter-Mancos
Mowry
Greater Green River Basin
Niobrara*
Unita Basin
Mancos
Park Basin
Denver Basin
Forest City Basin
Michigan Basin
Antrim
Utica
Marcellus
Illinois Basin
Appalachian Basin
San Joaquin Basin
Manning Canyon
Hermosa
Piceance Basin
Paradox Basin
Monterey-Temblor
Excello-Mulky
Cherokee Platform
New Albany
Pierre
Lewis
Monterey
Santa Maria-Ventura-Los Angeles Basins
San Juan Basin
Raton Basin
Anadarko Basin
Fayetteville
Chattanooga
Devonian (Ohio)
Woodford
Palo Duro Basin
Bend
Arkoma Basin
Black Warrior Basin
Conasauga
Abo-Yeso****
Glorieta-Yeso****
Ardmore Basin
Floyd
Valley & Ridge Province
Bone Spring****
Ft. Worth Basin
Barnett
Haynesville-Bossier
TX-LA-MS Salt Basin
Neal
Delaware**
Spraberry****
Permian Basin
Tuscaloosa
Eagle Ford
Western Gulf
Current play - Oldest stacked play
Current play - Intermediate depth/age stacked play
Current play - Shallowest/youngest stacked play
Prospective play
Basin
*Mixed shale & chalk play
**Mixed shale & limestone play
***Mixed shale & dolostone-siltstone-sandstone play
****Mixed shale & limestone-siltstone-sandstone play
Source: U.S. Energy Information Administration based on data from various published studies.
Updated: February 8, 2015
eia

Upstream Oil and Gas Emission Sources



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

- Artificial Lift Engines
- Associated Gas Venting
- Condensate Tanks
- Crude Oil Tanks
- Dehydrators

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

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

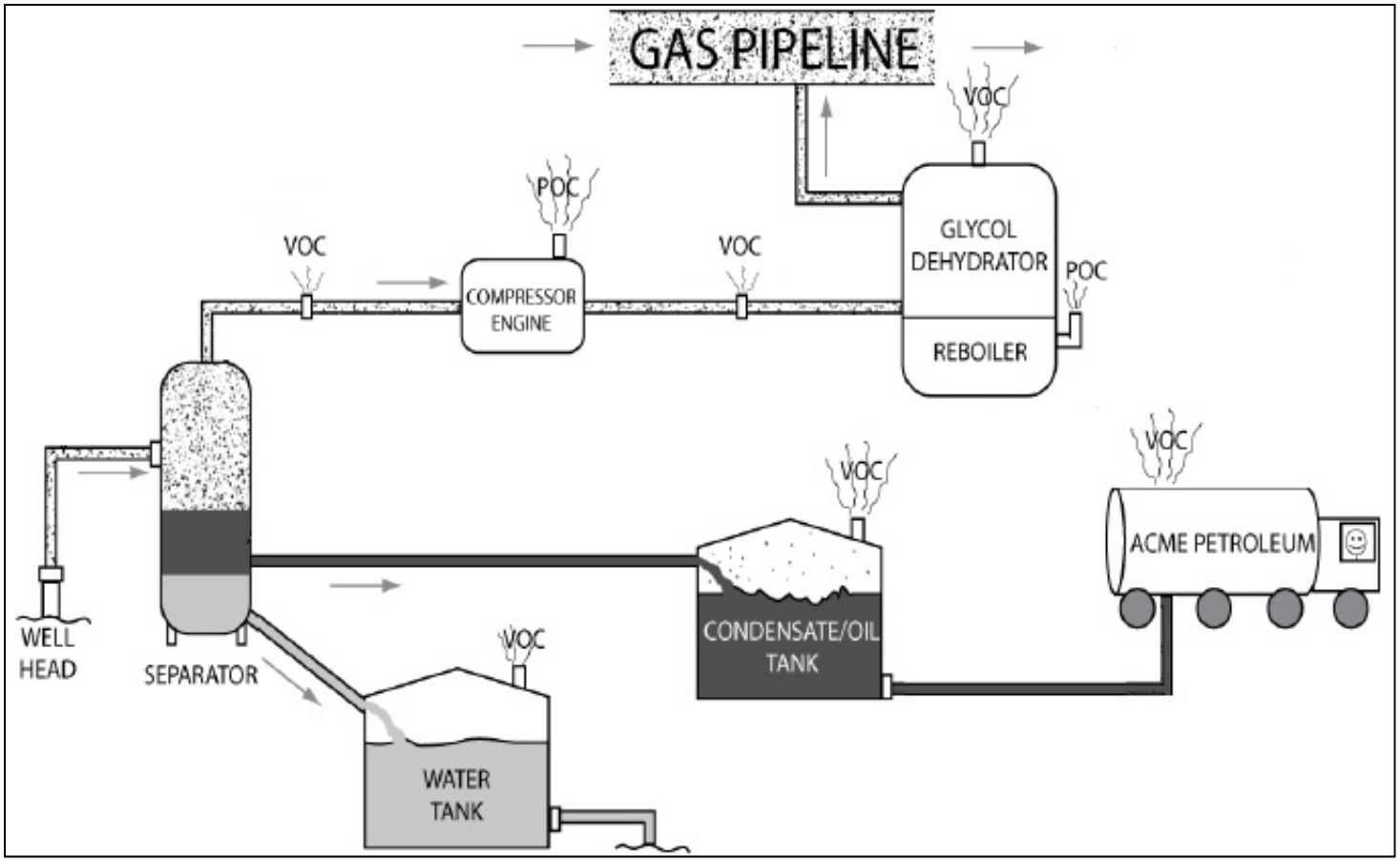
Well Completion Venting

- 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

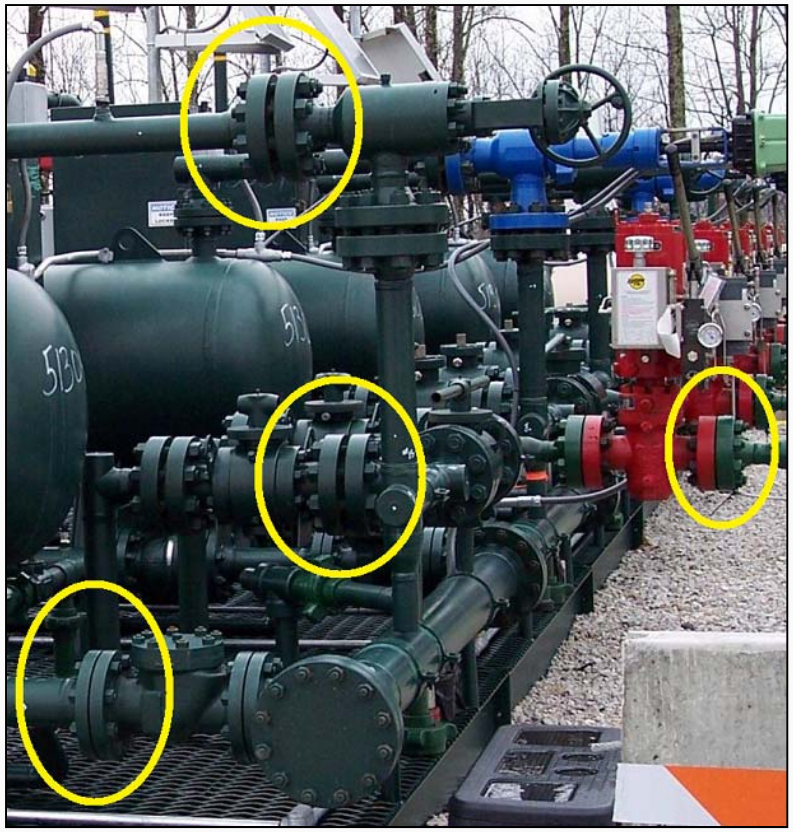
- Use glycol to remove water from gas stream to prevent corrosion or freezing issues downstream
- Small reboiler used to regenerate the glycol
- May be located at wellpad, or at centrally located gathering station

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

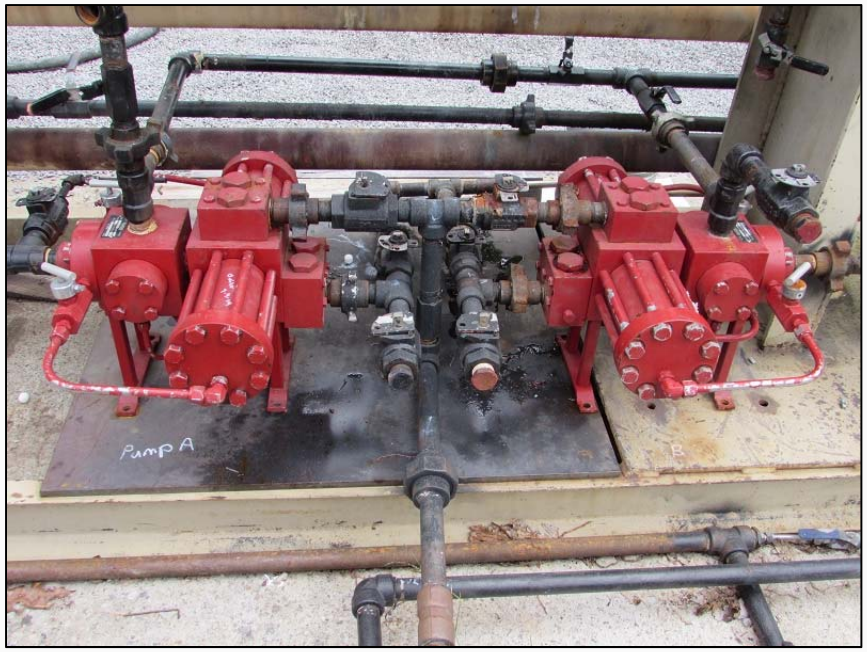


Fugitive Leaks

- 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
- Emission factors from “Protocol for Equipment Leak Emission Estimates” (EPA, 1995)

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)
  - H_2S content (to estimate SO_2)

Lateral Compressor Engines

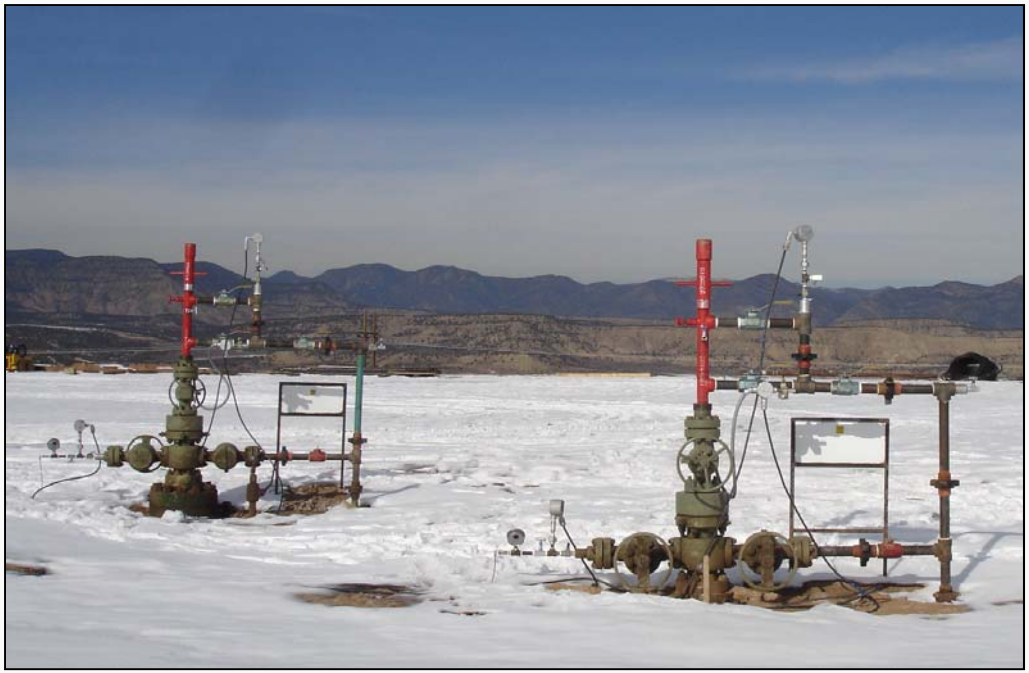
- Large “line” engines
- May serve ~10 to 100 wells
- Used at gathering or booster stations (mid-stream)
- Natural gas-fired
- Rich-burn or lean-burn

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)

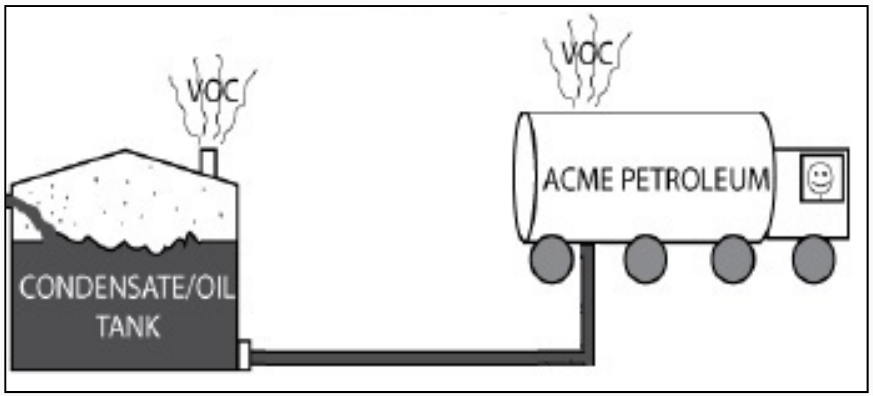


Liquids Unloading

- 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)
- 2nd 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