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Introduction

• Advances in drilling techniques over the past 10-15 years have led to a significant expansion in domestic oil and gas production

• In light of this expansion, and to address specific air quality concerns, Colorado has adopted a series of regulatory requirements to reduce air emissions from the oil and gas production sector

• These regulations, and their underlying air quality basis, may serve as a guideline for states considering how to best address oil and gas emissions in their areas
Overview

- Potential air quality bases for regulating hydrocarbon emissions from the oil and gas sector
  - Global climate change
  - Regional ozone
  - Local impacts
- Colorado regulatory requirements
- Other current and potential future air quality requirements
Oil and Gas Hydrocarbon Emissions

- Methane (CH\textsubscript{4})
- Volatile organic compounds (VOC)
  - hundreds of different compounds
- Hazardous air pollutants
  - Benzene
  - Toluene
  - Ethylbenzene
  - Xylene
Methane and Climate Change

• Methane is a potent greenhouse gas with a warming potential 25 times greater than CO$_2$ over a 100 year time span and 84 times over a 20 year time span.

• Reducing methane emissions in Colorado was consistent with state Climate Action Plan and directives from current Governor.

• Methane from oil and gas production is a relatively small part of overall greenhouse gas inventory:
  – Approximately 3.5% nationally
  – Approximately 7.7% in Colorado
Ozone

- O$_3$ or ground-level ozone – major contributor to smog
- Formed by complex chemical reaction of NO$_x$ and VOCs (ozone precursors), in the presence of sunlight
- Ozone (and its precursors) can be transported long distances by wind
- Common sources of ozone precursors include vehicles, industrial processes, and oil and gas production operations
- Current National Ambient Air Quality Standard set at 75 ppb, but EPA is currently considering lowering the standard to between 65-70 ppb
Current Ozone NAAQS
Nonattainment at 65 ppb (NAM)

Projected 8-Hour Ozone Nonattainment Areas

- Red: Monitored CBSAs and rural counties that would be violating a 65 ppb standard
- Orange: Unmonitored areas that are anticipated to violate a 65 ppb standard based on spatial modeling
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<th>Site Name</th>
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(Draft data for 2014) For NAAQS of 75 ppb
A 2011 Harvard study was designed to improve current modeling of “Policy-Relevant Background” (PRB) ozone to assist EPA in its current review of the ozone NAAQS.

- While "previous studies found no occurrences of PRB exceeding 60 ppbv," the authors found PRB exceeds that amount in the intermountain West (extending between the Sierra Nevada/Cascades Mountains to the west and the Rocky Mountains to the east) on a regular basis.

- “The annual 4th-highest PRB value in the model (representing the minimum standard achievable through suppression of North American anthropogenic emissions) is... 50-60 ppbv" in the region.

- As EPA has considered decreasing the current NAAQS from 75 ppbv to 60-70, "such high PRB values in the intermountain West suggest that special consideration of this region may be needed if the ozone NAAQS is decreased to a value in the 60-70 ppbv range."

The study also noted that as the NAAQS becomes more stringent and approaches the PRB, accurate specification of the PRB becomes increasingly important.
## 2018 DVF Projections O&G Sens Tests

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| Total   | 72.3 | 68.3 | 67.1 | -1.2 |
Colorado (9-County NAA) 2011 - Anthropogenic VOC Emissions
538 tons/day

- Point: 39.2 (7%)
- Area: 75.8 (14%)
- On-Road Mobile: 89.3 (17%)
- O&G (permitted & unpermitted): 26.5 (5%)
- Non-Road Mobile: 306.6 (57%)
Local Impacts of Oil and Gas Emissions in Colorado

• Odor issues

• Extensive anecdotal reports of health impacts from nearby residents

• Numerous health studies to try and quantify health impacts have been inconclusive
  – Disagreements over the meaning of these studies but all agree that more study is needed
Scientific Complexity and Uncertainty Associated with Assessing Local Health Effects

• How much is being emitted?
  – Large number of relatively small sources
  – Source to source variability
  – Source variability over time
  – Fugitive sources that are difficult to measure

• Impact on human health?
  – Uncertain exposure levels
  – Long latency period
  – Impact from other factors
Past Efforts in Colorado

• Prior to the early 2000’s oil and gas sector was considered to be an insignificant contributor to VOC emissions in Colorado

• Until 2003, condensate storage tanks at oil and gas production facilities were exempt from reporting and permitting requirements

• Little or no understanding of the potential for VOC leakage and venting at oil and gas production facilities
In early 2000’s Air Pollution Control Division (APCD) discovered that “flashing” at condensate storage tanks was a significant source of VOC emissions in Colorado.

- “flashing” occurs when petroleum liquid that is under high pressure underground is put into an atmospheric tank.
- Previously APCD assumed that emissions from tank were limited to evaporative losses (working and breathing losses).

For 2002 estimated flashing emissions in Denver area of 134 tons per day – Largest source of VOCs in the state.
Past Efforts in Colorado

• Rulemakings in 2004, 2006, and 2008 to reduce VOC emissions from oil and gas production sector in connection with efforts to meet ozone NAAQS
  – Storage tank controls (combustors or, less commonly vapor recovery)
  – Lower emitting pneumatic devices
  – Leak emissions from gas processing plants
  – Glycol dehydrator controls
2014 Rulemaking

• While past efforts initially resulted in significant emission decreases, dramatic rise in production offset ongoing gains
• Higher line pressures resulting from increased production compromised some of the benefit from storage tank controls
• Growing understanding of leaking and venting emissions and technological advances created additional reduction opportunities
• Interest in addressing methane emissions directly
Oil and gas related compounds

**Ethane**
Average 3-hr. samples (6 a.m. - 9 a.m.)

- Aug - Sep 2003
- Jun - Aug 2006
- Dec 2011 - Dec 2012
- Jan 2013 - Dec 2013

**Propane**
Average 3-hr. samples (6 a.m. - 9 a.m.)

- Aug - Sep 2003
- Jun - Aug 2006
- Dec 2011 - Dec 2012
- Jan 2013 - Dec 2013
2014 Emission Reduction Strategies

• 2014 rules targeted VOC and methane emissions from the oil and gas production sector
  – 1st in the nation rules to specifically require methane emission reductions from O&G

• Rules apply statewide but most of the costs and benefits will be for the Denver ozone non-attainment area

• New rules establish emission reduction requirements for the largest O&G source categories
  – Tanks
  – Fugitives/Venting
  – Pneumatic devices
Oil and Gas VOC Sources

Colorado (Statewide) 2011 O&G Sources VOC Emissions - 576 tons/day

- O&G - Tanks: 344.7 tons/day (60%)
- O&G Area - Venting/Fugitives: 116.4 tons/day (20%)
- O&G Area - Pneumatics/Pumps: 51.4 tons/day (9%)
- O&G Point - Industrial Processes: 29.9 tons/day (5%)
- O&G Point - Evaporation: 19.4 tons/day (3%)
- O&G Point - Engines: 11.9 tons/day (2%)
- O&G Area - Engines/Rigs: 3.0 tons/day (1%)
Storage Tank Reduction Strategies

• Expand control requirements for storage tanks
  – Lower control threshold from 20 tons per year to 6 tons per year
  – Include crude oil and produced water storage tanks
  – Require controls during the first 90 days of production statewide

• Improve capture of emissions at controlled tanks
  – Controlled tanks must be operated without venting to the atmosphere
  – Establish requirements for Storage Tank Emission Management systems (STEM)
    • Capture performance evaluation
    • Certified design to minimize emissions
    • Extensive instrument based monitoring
    • Continual improvement
Storage Tank Capture Requirements

• Emission reduction benefits from storage tank controls premised on capturing emissions and routing them to the control device

• Input pressure for many controlled tanks is too high (above atmospheric)
  – During high pressure dumps to the tank, the pressure relief valve (PRV) and thief hatch may release to prevent tank failure
  – Results in uncontrolled flashing losses from thief hatch and PRV
Incomplete capture of storage tank emissions
Established LDAR requirements for compressor stations and well production facilities

- Frequent monitoring using Method 21 or infrared (IR) cameras
  - Tiered monitoring schedule to focus on the highest emitting facilities and reduce the burdens on smaller facilities
  - Most comprehensive leak detection program for oil and gas facilities in the nation
- Repair schedule for identified leaks
- Recordkeeping and reporting requirements
Leak on loose hammer union on pipe leading to Flare Combustor.
Additional Emission Reduction Strategies

• Expand low-bleed pneumatic controller requirements statewide

• Require capture or control of the gas stream at well production facilities

• Establish requirements to minimize emissions during well maintenance
  ‣ Require auto-igniters on all combustion devices

• Expand control requirements for glycol dehydrators
  ‐ Lower control threshold from 15 tons per year to 6 tons per year
  ‐ More stringent threshold for facilities near populated areas
Recent Federal Efforts

• NSPS OOOO adopted in 2012 (amendments in 2013 and 2014)
  – Aimed at VOC emissions with CH$_4$ co-benefit
  – New facilities only
  – Storage tank controls (6 tpy and greater)
  – Pneumatic controllers
  – Compressor engines
  – More stringent equipment leak standards for gas plants
Recent Federal Efforts

• Ft. Berthold Indian Reservation Federal Implementation Plan
  – New and some existing facilities (any completion/recompletion activities on or after August 12, 2007)
  – Well completion activities
    • at least 90% control
  – Gas production
    • inject into gathering line or send to an enclosed combustor capable of achieving 98% control
  – Storage tanks
    • capture vapors and route to pipeline or 98% control enclosed combustion device
Recent North Dakota Efforts

• 2011 Bakken Pool Guidance
  – Storage tanks
  – Dehydration units
  – Treater flares
  – Pneumatic pumps
Recent North Dakota Efforts

- North Dakota Industrial Commission Gas Capture Requirements
  - Rapid development of oil wells and lack of gas pipeline infra-structure led to extensive flaring of gas
    - estimates that 1/3\textsuperscript{rd} of gas produced in North Dakota was being flared
  - Phased schedule to increase gas capture from 74% by October 1, 2014 to 90% by October 1, 2020
  - Production caps if certain capture requirements not being achieved
Future Federal Efforts

• Planned EPA efforts to enhance VOC emission controls and directly regulate methane from new oil and gas production facilities
  – Compressors
  – Well completions
  – Leaks
  – Liquids unloading (well-maintenance
  – Pneumatic devices

• Methane regulation could trigger requirements for existing facilities under Clean Air Act section 111(d)
Conclusions

• While Colorado’s oil and gas regulations may serve as a guideline for other states, they are based on specific air quality issues that may not be applicable elsewhere.

• In developing oil and gas regulations states need to consider specific air quality needs, emission inventories and available control technologies.

• Specifics of upcoming federal regulation are unclear but could significantly impact new and existing oil and gas production operations.