NOx Emissions from Natural Gas Production and Use: A Bottom-Up Inventory Perspective

AQAST 8
Georgia Institute of Technology
December 2 – 4, 2014

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Summer 2014 Research Experiences for Undergraduates
Objectives

- Examine inventory-based estimates of NOx emissions from oil and gas production for comparison with top-down perspectives
- Place production emissions in context with emissions from end uses
- Focus on NOx due to interest in satellite observations; role in ozone, N-deposition & regional haze; relatively limited research attention compared to VOCs and methane
AirWaterGas SRN Project

- AirWaterGas: What We Know, What We Don’t Know, and What We Hope to Learn about Oil and Gas Development
- [http://airwatergas.org/](http://airwatergas.org/)
- University of Colorado Boulder and eight partner research organizations
- Duration: 2012 – 2017
- Geographic focus: Rocky Mountain Region
- Research thrusts: well integrity, water quantity and quality, air quality, health effects, socio-economic impacts
How do production trends compare across basins?

Source: COGCC (2014)
How do production trends compare across basins?

Source: WOGCC (2014)
How Big Are Individual NOx Sources?

Location of upstream oil and gas sources of NOx emissions in 2011 in Colorado (tpy)

Source:
Dale Wells, CDPHE (2014);
Map prepared by Phil Swisher
How do sources compare across basins?

Source: Bar-Illan et al. 2012a,b; 2013a,b
Emissions for 2008
What Control Requirements Apply?

Compressors

- Federal New Source Performance Standards for Stationary Compression Ignition Engines (June 2006)
  - New, modified or reconstructed engines
  - Match equivalent “tier” standards for non-road engines

  - Emissions limits for new, modified or relocated engines

- Utah BLM Greater Natural Buttes ROD (2012): electrification of ~50% of compressor engines

- NM BLM Farmington RMP (2003): tighter limits for new and replacement engines
What Control Requirements Apply?

Drill Rigs

- Federal Non-Road Diesel Standards
  - New, modified or reconstructed engines
  - “Tier” standards by size and model year

- Utah BLM Greater Natural Buttes ROD (2012): low-emissions drill rigs

- Pinedale Anticline Project Area operators (since 2008): selective catalytic reduction on all drill rig engines

How Do Different Inventories Compare?

NOx Emissions Comparison for the Denver-Julesburg Basin

Source: Compiled by A. Nagurney. Inventory year shown in ().
NG for electricity generation in Colorado: 90 million mcf in 2013

Sources: Compiled by A. Nagurney. Pre-production & production, West Jump (2008); Processing, transmission, distribution: CDPHE (2011); Electrical combustion: EPA Air Markets Division (2011)
Residential use in Colorado: 140 million mcf in 2013

Sources: Compiled by A. Nagurney. Pre-production & production, West Jump (2008); Processing, transmission, distribution: CDPHE (2011); Residential combustion: EPA NEI (2011)
Conclusions

- Upstream emissions appear to be significant in the NG life cycle
- As with VOC and methane, understanding magnitude and trends of NOx emissions from oil and gas production warrants greater attention
- Inventories suggest drill rigs are important with new development; compressor engines dominate during production
- Age of equipment is critical, not well tracked
- Electrification, use of add-on controls varies widely
Acknowledgments

• National Science Foundation, Sustainable Research Networks Grant No. CBET-1240584

• CU Boulder Environmental Sustainability Research Experiences for Undergraduates http://www.colorado.edu/reu, NSF Award No. 1263385

• Phil Swisher, Western Washington University

• Dale Wells, Colorado Department of Public Health and Environment
Utah Gas Production

Source: Utah Oil and Gas (2014)
NOx Emissions Comparison for the Powder River Basin

Source: Compiled by A. Nagurney. Inventory year shown in ().
NOx Emissions Comparision for the Piceance Basin

- WRAP Phase III (2006)
- WRAP Updated Phase III (2009)
- West Jump (2008)
- EPA National Emissions Inventory (2011)
- Department of Public Health (2011)

Source: Compiled by A. Nagurney. Inventory year shown in ().
Power Generation Isn’t the Only End-Use

Source: EIA, 2014

Colorado Natural Gas Consumption (mcf)

Year

Natural Gas Consumption (mcf)
0 20000000 40000000 60000000 80000000 100000000 120000000 140000000 160000000

Residential
Commercial
Industrial
Electric Power
AirWaterGas Research Thrusts

- Natural gas infrastructure – evaluation of well bore integrity, probabilities of casing and cement failure
- Water quantity – future water supply portfolios, alterations of groundwater flow
- Water quality – potential for surface or groundwater contamination, treatment of flowback and produced water
- Health effects – potential for health effects from exposure to chemicals associated with production activities
- Socio-ecological impacts – overall assessment of risks and benefits in communities with oil and gas development
- Air quality – improving emissions estimates and assessing the balance of air quality impacts