Emissions Inventory & Ambient Air Monitoring of Natural Gas Production in the Fayetteville Shale

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The Fayetteville Shale Air Quality study was performed by the Arkansas Department of Environmental Quality. David Lyon’s current affiliation is with Environmental Defense Fund (EDF), which was not involved with this study. Consequently, this paper does not necessarily reflect the views of EDF.
Introduction

• EPA Region 6 awarded ADEQ an energy grant in 2010 to develop an emissions inventory and perform ambient air monitoring of natural gas production in the Fayetteville Shale region of Arkansas.

• An emissions inventory was developed to estimate annual county-level criteria pollutant and greenhouse gas emissions from Fayetteville Shale natural gas production activities for inclusion in the 2008 NEI.

• Ambient air monitoring was performed around the perimeter of 15 sites including compressor stations and new wells undergoing drilling or hydraulic fracturing.
Emissions Inventory

- Annual emissions from 2008 were estimated at the county-level for the 10 counties with active wells.
  - Pollutants included NO$_X$, VOC, PM$_{10}$, CO, SO$_2$, CH$_4$, & CO$_2$
  - Emission sources included compressor engines, drilling rigs, hydraulic fracturing pumps, well venting, and fugitive emissions from production, processing, & transmission.
  - Data submitted to EPA for inclusion in 2008 NEI version 2.0
Emissions Inventory

- Compressor engine emissions were conservatively assumed to equal permitted limits adjusted by months operational in 2008.
  - [http://www.adeq.state.ar.us/home/pdssql/pds.asp](http://www.adeq.state.ar.us/home/pdssql/pds.asp)

- Drilling rig, hydraulic fracturing pump, well venting, and fugitive emissions were based on Armendariz 2009 and Bar-Ilan 2008.

- Emission equation parameters were modified to reflect typical operating procedures and gas composition.
  - Data were provided by Southwestern Energy, the largest producer.
  - Fayetteville Shale produces a dry gas with low VOC content (0.05%).
## Emissions Inventory by County

<table>
<thead>
<tr>
<th>County</th>
<th>Production</th>
<th>Active Wells</th>
<th>New Wells</th>
<th>NO\textsubscript{x}</th>
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<th>CO</th>
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<td><strong>Total</strong></td>
<td><strong>273,355</strong></td>
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## Emissions Inventory by Source

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<th>Source</th>
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<th>PM$_{10}$</th>
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Emissions Inventory Summary

- Compressor engines were the primary source of most pollutants, with the exception of CH₄, which was emitted mainly from well venting and fugitive sources.

- VOC emissions were relatively lower than regions such as the Barnett Shale due to the low VOC content of gas.

- Fayetteville Shale gas production activities in 2008 contributed < 1% of statewide emissions from stationary, mobile, & area sources for all pollutants except NOₓ (2.6%).

- Emissions in 2011 were likely greater than 2008 since both the number of active wells & production was ≈3X higher.
Ambient Air Monitoring

- Air quality was monitored for ≈ 8 hours around the perimeter of 15 sites including compressor stations & new well pads.
- Measurements included VOC, NO, & NO$_2$ concentrations and temperature, wind speed, & wind direction.
- Data were collected from November 2010 – June 2011.
  - Analysis included general linear model of pollutant concentrations.
Sites Studied

Hydraulic Fracturing Sites (3)
Drilling Sites (6)
Compressor Stations (4)
Control Site (1)
Air Monitoring Equipment

RAE Systems
AreaRAEs
MDLs =
2 ppm NO
0.3 ppm NO₂
0.1 ppm VOC

RAE Systems
ppbRAE PID
MDL =
20 ppb VOC

Coastal
Environmental
Weatherpak
Monitoring Method
Monitoring Method
Air Monitoring Summary

• NO & NO$_2$ were below detection limits at all sites.

• Average VOC concentrations were below 100 ppb at compressor station & hydraulic fracturing sites.

• VOC at drilling sites was typically elevated with 8 hr & 15 min averages reaching 0.7 & 5.3 ppm, respectively.
  – GLMs showed statistically significant relationships between VOC concentration, location, & wind direction.
  – Open tanks of oil-based drilling mud & cuttings were the likely source of elevated VOC concentrations.

• Detailed presentation on air monitoring results given by Toby Chu at 2012 National Air Quality Conference.
Conclusions

• Fayetteville Shale gas production activities emit large quantities of air pollutants, primarily $\text{NO}_x$, CH$_4$, & CO$_2$.
  – Dry gas & lack of condensate tanks result in low VOC emissions.
  – Fugitive emission estimates were based on gas leakage rates from 1996 EPA/GRI study and have high uncertainty.
  – Well venting emissions may be lower with green completions.

• There were no apparent serious ambient air quality issues.
  – Mud tanks probably contributed to elevated VOC concentrations.
  – VOC was not speciated; therefore hazardous air pollutants such as benzene may be present at harmful concentrations.
  – $\text{NO}_x$ emissions may contribute to regional ozone formation.
Acknowledgements

- EPA Region 6
- Southwestern Energy
- Chesapeake Energy
- BHP Billiton
- Scot Stinson
- Jay Justice
References


• Bar-Ilan, A., R. Parikh, J. Grant, T. Shah, and A. Pollack. 2008. Recommendations for Improvements to the CENRAP States’ Oil and Gas Emissions Inventories. ENVIRON.
Questions?

• Full report available for download on ADEQ website:
  - [http://www.adeq.state.ar.us/air/pdfs/fayetteville_shale_air_quality_report.pdf](http://www.adeq.state.ar.us/air/pdfs/fayetteville_shale_air_quality_report.pdf)

• For questions about the report, contact:
  - Mike Bates, Arkansas DEQ, Air Division Chief,
    bates@adeq.state.ar.us

• For technical questions, contact:
  - David Lyon, Environmental Defense Fund, Research Analyst
    dlyon@edf.org