Analysis of *Emissions from Natural Gas Production in the Barnett Shale*

1. Barnett Shale Emissions Inventory (EI). The author's assertions are based on incomparable data and exaggerate the relative significance of the emissions from the Barnett Shale with regard to ozone formation in the Dallas-Fort Worth (DFW) ozone nonattainment area.

- For example, the report compares oil and natural gas exploration and production (E&P) nitrogen oxides (NO_X) emissions and volatile organic compounds (VOC) emissions from a 21-county area encompassing the Barnett Shale to only the on-road mobile portion of the nine-county DFW ozone nonattainment area EI.
- On-road mobile emissions comprise 46 percent of the anthropogenic Barnett Shale NO_X EI and approximately 60 percent of the DFW area NO_X EI.
- NO_X emissions from E&P sources are well characterized in the TCEQ point and area source emissions inventories, and are not "unknown" or "unnoticed," as the report claims. Comparisons presented in the table below illustrate this point.
- The 2007 TCEQ engine survey categorized area source engines by type, load, and horsepower rating, as well as estimating NO_X emissions. These data were not readily available in the emissions inventory, but were necessary to evaluate the effectiveness of different control strategies.
- This TCEQ survey verified that NO_X emissions estimates in the inventory were substantially correct. By confusing NO_X emissions estimates with engine specifications, Dr. Armendariz misrepresents the quality and integrity of the TCEQ emissions inventory.

Barnett Shale 21-County Area Emissions Inventory Comparison

Data Source	VOC Emissions (tpd)	NO_X Emissions (tpd)
2005 TCEQ Oil and Gas EI	122	106
2005 TCEQ Periodic EI (all emissions sources, including biogenic)	1659	535
2007 Annual Average Oil and Gas EI from Armendariz Report (Table 21-1)	100	56

2. Ozone Chemistry. In an attempt to simplify comparisons between source categories, Dr. Armendariz has combined the NO_X and VOC emissions to create a factor alternately called "smog forming compounds" or "Ozone and Particulate Matter Precursors." Combining NO_X and VOC emissions creates an unrealistic large number and over-simplifies the chemistry that underlies ozone formation in the DFW area. Keeping NO_X and VOC emissions separate is critical because the two emissions categories have significantly different impact on ozone formation.

- Photochemical modeling has shown that ozone is much more responsive to NO_X emissions than to VOC emissions. Thus, reducing NO_X emissions is the most effective path to controlling ozone formation.

The table below shows the amounts of NO_X and VOC emissions contributed by various source categories in the DFW area, as documented in the DFW Eight-Hour State Implementation Plan (SIP) revision, adopted by the Commission on May 23, 2007. For NO_X emissions, on-road mobile sources are the largest single category, followed by non-road sources. For VOC, the largest anthropogenic contributions come from area sources, but total anthropogenic VOC emissions are dwarfed by the natural emissions from biogenic sources.

- Since the contribution from biogenic VOC is large enough to carry the photochemical reactions forward, controlling anthropogenic VOC is largely ineffective.

DFW 9-County 2009 Summer Baseline Emissions Estimates from 2007 DFW Ozone SIP

Category	NO_X Emissions (tpd)	VOC Emissions (tpd)
DFW 9-County On-Road Mobile	184	92
DFW 9-County Point Sources	59	30
DFW 9- County Area Sources	44	180
DFW 9- County Non-Road	107	38
DFW 9-County Biogenic	52	642
DFW 9-County Total	446	982

Once the 2009 estimates of NO_X and VOC emissions in the report's analysis are separated, it is clear that the majority of Barnett shale emissions are due to the VOC portion of the inventory. The report states that reducing both NO_X and VOC emissions ("smog forming compounds") through the proposed control strategies would result in "air quality benefits," implying that ozone formation in the DFW nonattainment area would be reduced. However, the report does not distinguish between potential benefits of the different controls with regards to ozone formation in the DFW area. Since the response to NO_X reductions is much stronger than the response to VOC emissions, this distinction is critical.

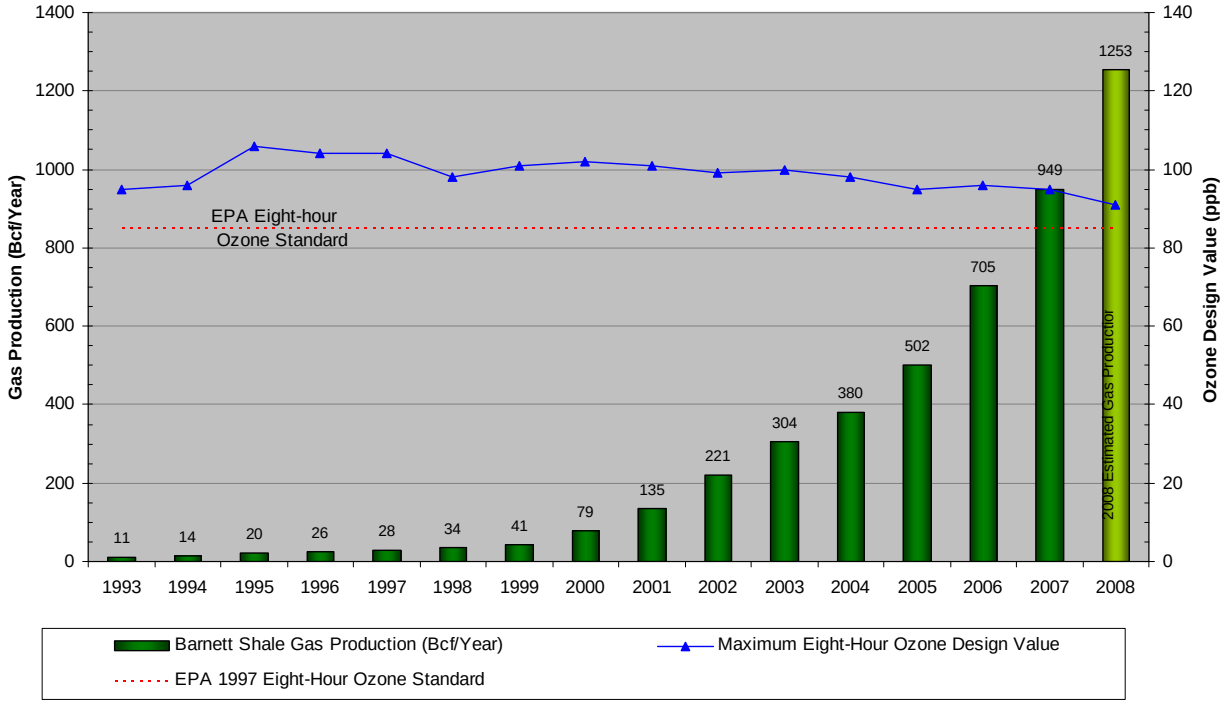
Barnett 21-County 2009 Peak Summer Emissions (from Armendariz, Table 21-2)

Category	NO_X Emissions (tpd)	VOC Emissions (tpd)
Total Emissions from Oil/Gas Sources	51	255

3. Gas Production and Ozone Trends. The report suggests that the ozone in the DFW area is aggravated by emissions from the Barnett Shale. The graph below shows the ozone design values and annual Barnett Shale gas production statistics since 1993 (from the Railroad Commission). Total 2008 gas production is estimated and probably low since the December production data has not yet been released.

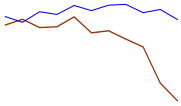
- Despite the dramatic increases in Barnett shale gas production since 2000, the long term trend shows that ozone design values measured in the DFW area have been decreasing.

Dallas-Ft. Worth Ozone Design Values Compared to Barnett Shale Natural Gas Production



4. Forecasting Activity in the Barnett Shale. The report assumes that Barnett Shale production is continually increasing, and forecasts emissions growth using a least-squares method to extrapolate from historical production levels. However, both rig counts and production levels vary, and the production for calendar year 2009 is predicted to plateau or decrease due to economic conditions and increased use of renewable options.

- While drilling is anticipated to continue, drilling activity levels have slowed since October 2008 based on recent rig counts.
- Compared to 2007 data, 2008 monthly Barnett Shale **oil** and **gas** production trends are leveling or decreasing.



- Based on economic indicators, 2008 might represent the peak production and therefore the peak E&P emissions from the Barnett Shale region.
- The report's emissions projection method appears to overestimate growth in NO_X, VOC, and hazardous air pollutant emissions.

Forecasts therefore need to reflect the leveling in drilling and production to accurately project emissions. Further, adding more control strategies based on short term changes in emissions trends is often not cost effective and generates few benefits for improving long-term air quality.

5. Control Strategy Development. The report briefly discusses the East Texas Combustion rule and suggests (page 28) that these rules or the new rules that apply inside the DFW ozone nonattainment area be expanded to all Barnett Shale counties. Six counties were excluded from the East Texas Combustion rule at adoption: Bosque, Cooke, Grayson, Hood, Somervell, and Wise. All but Grayson are in the Barnett Shale.

- These six counties were excluded from the final rule because photochemical modeling showed that emissions from those counties have very little impact on the DFW nonattainment area. Ozone concentrations in the nonattainment area would be only reduced by approximately 0.05 ppb by applying the East Texas Combustion rule to these six counties.
- Applying either existing DFW rules or the East Texas Combustion rules to the other Barnett Shale counties might have benefits in those counties, but is not likely to have any benefits in the DFW nonattainment area itself.

The report's proposed electrification of the Barnett Shale compressor engine fleet could have some emissions reduction benefits, but the report does not address several potential problems.

- Many Barnett Shale compressor engines are remotely located, where connecting to the grid would neither be simple nor inexpensive. The report's cost analysis does not appear to account for grid connection upgrades or new transmission lines, much less the cost/effectiveness ratio.
- During the 2000 Houston-Galveston-Brazoria SIP (90 percent control level), the TCEQ proposed emission standards for large compressor stations that assumed the partial electrification of the compressor engine fleet (these emissions standards were subsequently revised to the final 80 percent control level).
  - The total capital cost estimate was $32.5 million for 42,500 hp capacity of new electric compressors; upgrades to the electric transmission lines were estimated at an additional $700,000 per mile (August 25, 2000, Texas Register, 25 TexReg 8292).
  - Smaller compressor stations and wellhead compressors were excluded from that rule proposal because of the substantial costs for new transmission lines.

The TCEQ has discussed the concept of compressor engine fleet electrification with representatives from the Electric Reliability Council of Texas (ERCOT), who have expressed some concerns.

  - Electric motors can create more grid instability than other users, and significant numbers of large electric compressor motors could pose challenges for ERCOT.
  - Finally, an increase in electric demand may shift the burden to power plants and possibly increase NO_X emissions. Limits exist on the amount of power that can be imported into the DFW region; therefore, it is likely that compressor fleet electrification would result in a net increase in NO_X emissions at local power plants.

Depending on where these consequent emission increases occur, ambient ozone could increase rather than decrease by effecting these regulations.

6. Emissions Inventory Improvement. The TCEQ has recently completed numerous projects to improve emissions estimates for Barnett Shale gas activities and oil and gas operations in general.

2005 and 2007: Remote Sensing VOC Projects identified many oilfield storage tanks with significant hydrocarbon plumes. The TCEQ is actively conducting investigations and outreach to address these emissions.

2006: Identified significant VOC flash emissions from upstream oil and gas storage tanks and developed emissions factors to quantify these emissions.

2007: Drilling rigs emissions quantification.

2007: Dallas-Fort Worth nonattainment area engine survey to characterize engine fleet.

2008: Research project to identify the most representative calculation methodologies for upstream oil and gas storage tank emissions (anticipated completion in spring 2009).