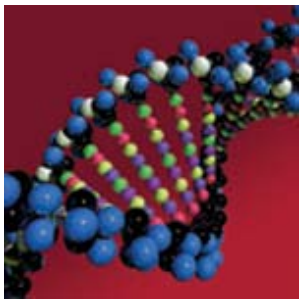
Emission Inventories for Natural Gas Exploration and Production in the Haynesville Shale


Presentation to the NETAC
Technical Committee

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The Haynesville Shale: Background

- Unconventional natural gas reservoir which is 10,000-13,000 feet below the surface of Northeast Texas/Northwest Louisiana
- Haynesville Shale may be one of largest natural gas reserves in the U.S.
- Drilling began in 2008
- Despite economic downturn and fall in price of natural gas since 2008, development of the Haynesville Shale has continued

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Emission Inventory for the Haynesville Shale

- The development of natural gas resources in the Haynesville Shale is likely to generate significant emissions of ozone precursors
- NOx
  - drilling, rock fracturing
  - gas compressor engines
- VOCs
  - Venting/completion/fugitives
  - Dehydration
- What effect will development in the Haynesville Shale have on Northeast Texas ozone?
  - Develop an emission inventory for the Haynesville Shale
  - Evaluate Haynesville Shale impacts using NETAC 2012 ozone model

Emission Inventory Scope

- Emission inventories developed for 2009-2020
  - Detailed inventory for 2012, the future year for NETAC ozone model
- Red counties define geographic extent of Haynesville for this study
  - Based on TRRC and LDNR well data as of March, 2009

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Projecting Future Development and Emissions

- Projections of future year activity based on
  - Number of new wells drilled each year
  - Well productivity
- Allows calculation of formation-wide
  - Well count
  - Gas production
- Once well count and gas production are forecast, can develop an emission inventory for exploration and production activity for the entire Haynesville Shale

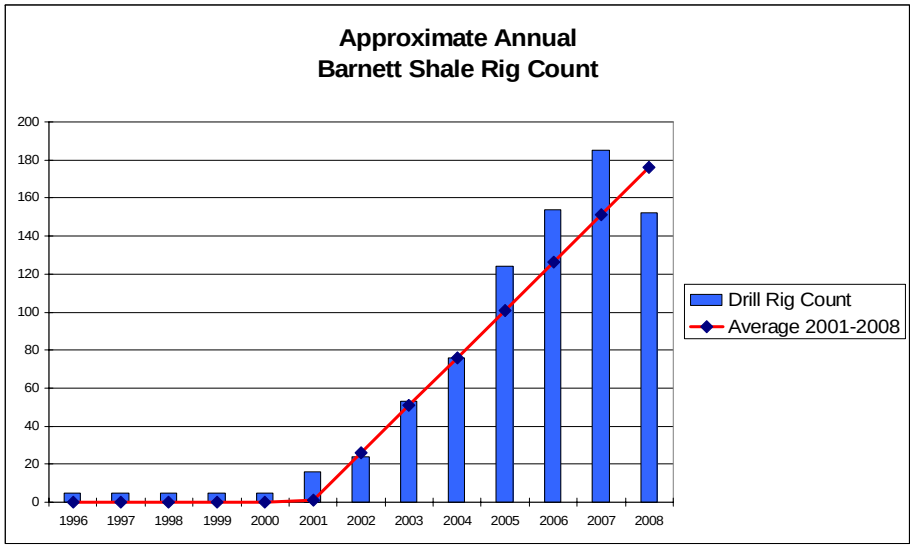
Uncertainties in Projecting Future Development

- Is it profitable to develop the Haynesville Shale?
  - Price of natural gas
  - Demand for natural gas
  - Total recoverable reserves
  - Availability of drill rigs and gas transportation and processing infrastructure
- Profitable compared to other formations?
  - Natural gas supply from other formations in the U.S.
  - Comparative productivity of Haynesville Shale wells
  - Cost of leasing and drilling in Haynesville compared to other formations

Data

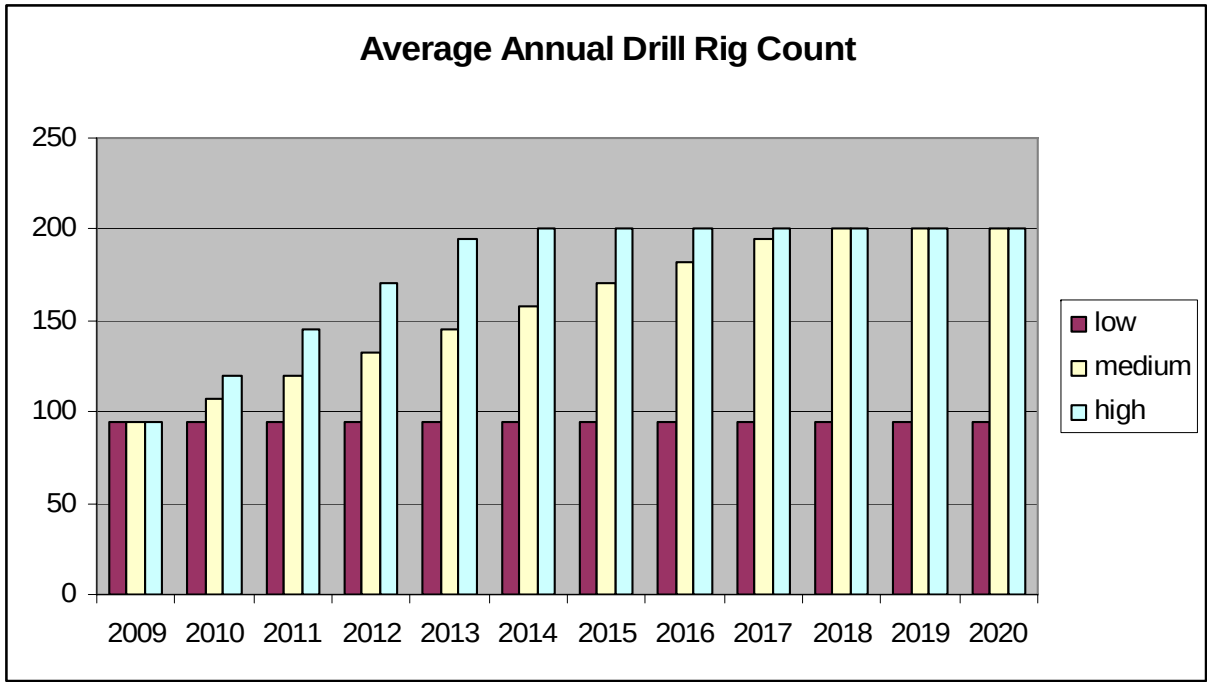
- Contacted TRRC, TCEQ, and LDNR regarding E&P activity in the Haynesville Shale
- Survey asking about current and projected activity and equipment use was sent to producers identified on company web pages and stockholder and VC reports as being major leaseholders in the Haynesville Shale
  - XTO, Chesapeake, Petrohawk, EOG, EnCana, Shell, BP, Devon and El Paso
  - All companies declined to participate
- Used data from state agencies and available literature to estimate future year activity
- Inventory development based on equipment data from CENRAP and WRAP Phase III Oil and Gas Emission Inventories

Base and Future Year Drill Rig Counts



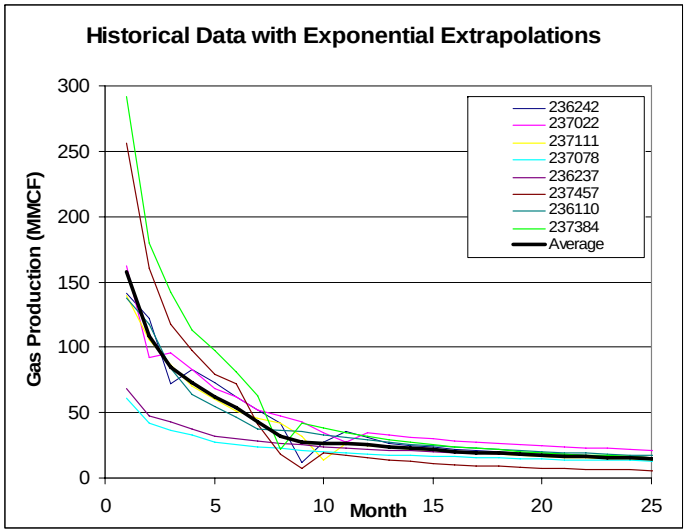
- Use Baker-Hughes drill rig database to determine number of wells currently drilling in the Haynesville Shale
- Use historical record of activity in the nearby Barnett Shale to project future activity in the Haynesville Shale

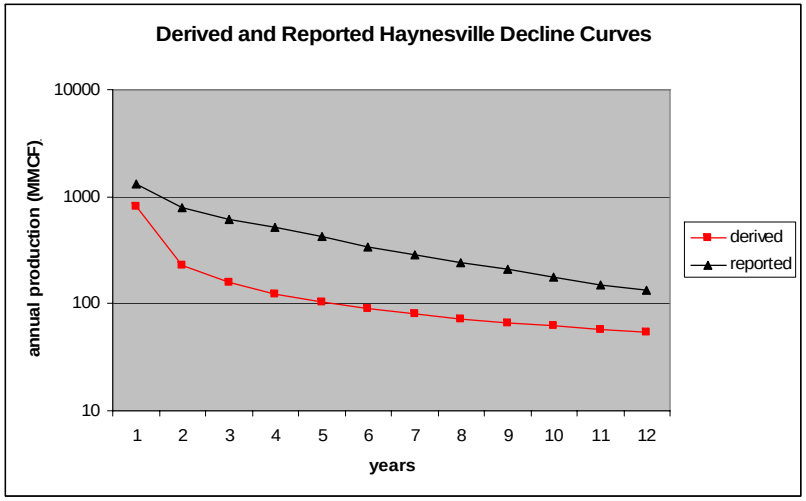
Drill Rig Projections: 3 Scenarios



- Start with current rigs operating in Haynesville as of March 2009
- Low scenario: leave current number of drill rigs fixed
- High scenario: use 2001-2008 Barnett Shale rig count growth, cap growth at 200 rigs
- Moderate: 50% of aggressive scenario

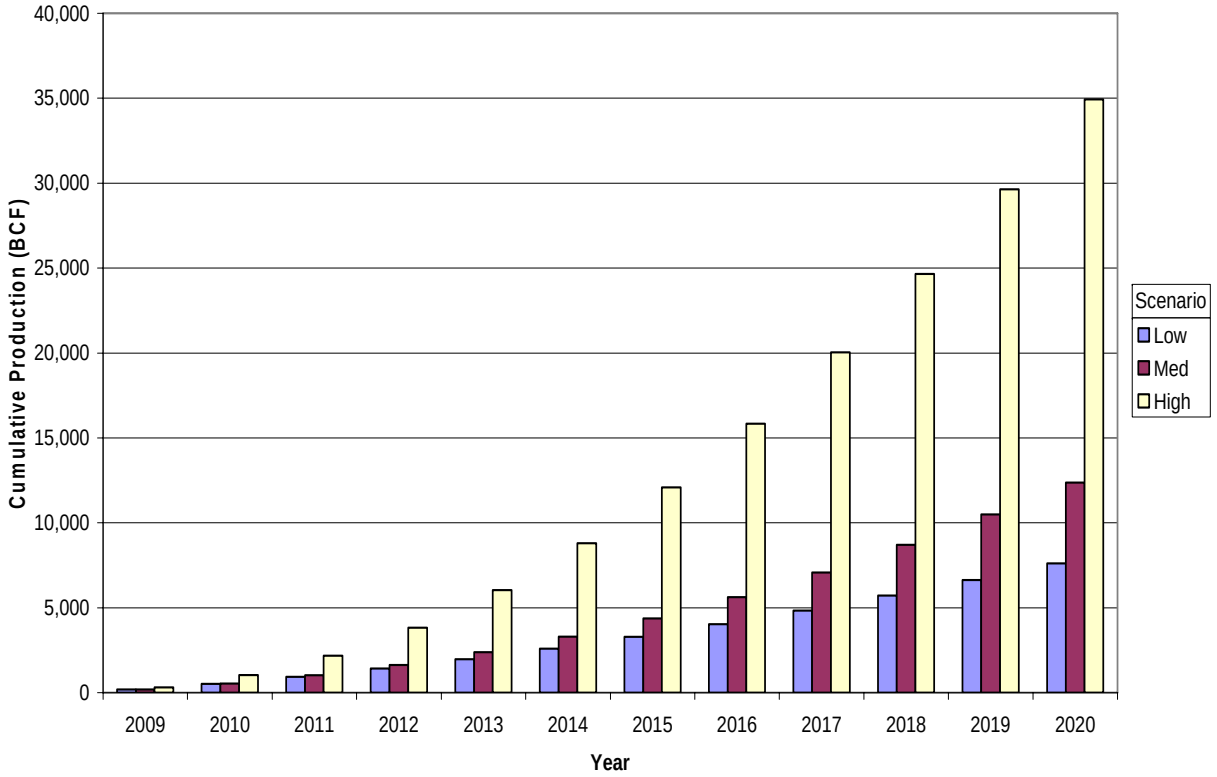
Calculating Decline in Per Well Production





- Peak gas production occurs right after drilling
  - Production declines thereafter as gas reservoir is drained
- Select 8 Haynesville wells with longest history
- Extrapolate using exponential fit
- Multiply number of active wells by annual production rate determined from decline curve to estimate total Haynesville Shale production in a given year

Projected Cumulative Gas Production in the Haynesville Shale: 2009-2020



- 2020 production estimates range from 7.6-35 TCF
- Within range of published estimates of recoverable reserves (7-250 TCF)
- Barnett Shale reserves estimated to be 25-50 TCF
- All estimates highly uncertain-will be refined as Haynesville Shale is explored

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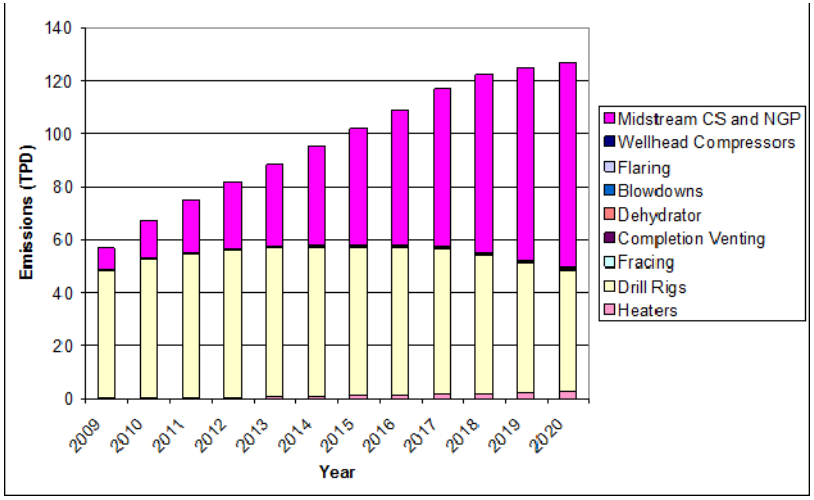
Emission Inventory

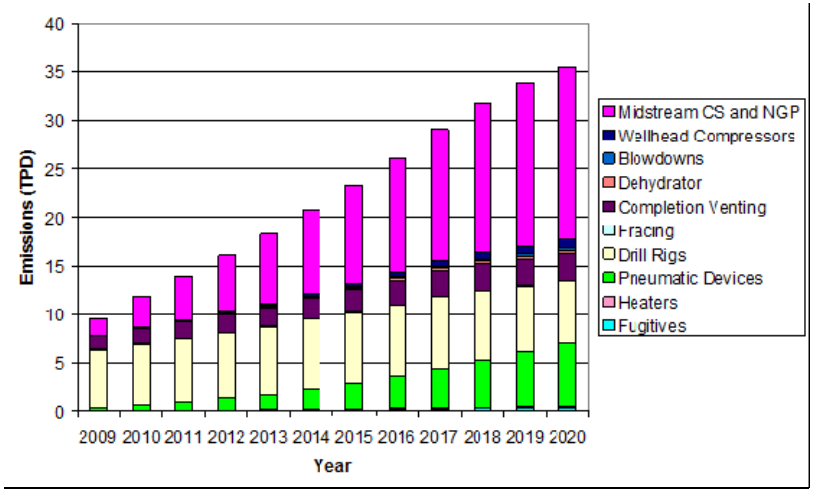
- Estimate 2009 base year ozone precursor emissions for each major source category (drill rigs, well venting, etc.)
- Project base year emissions to each future year, including effects of growth and applicable controls (NSPS, East Texas Combustion Rule, etc.)
- Equipment data from CENRAP and WRAP Phase III emission inventories
  - Equipment typically used at wells, emission factors, load
  - Activity data-how many hours per year?

Haynesville Emissions

NOx: Moderate Scenario



VOC: Moderate Scenario



- Largest NOx and VOC source categories are
  - midstream compression and natural gas processing (NGP)
  - drill rigs
- 2012 NOx emissions:
  - 61 tons/day, low scenario
  - 82 tons/day, moderate scenario
  - 140 tons/day, high scenario
- 2020 NOx emissions:
  - 64 tons/day, low scenario
  - 127 tons/day, moderate scenario
  - 267 tons/day, high scenario

Comparison with NETAC 2005 Inventory

- The moderate scenario projection of 82 tons/day NOx in 2012 is
  - Equal to the total 2005 NOx emissions from all of the Haynesville counties in Texas
  - About 30% of the total 5-County 2005 NOx inventory
- For the low development scenario, the Haynesville Shale 2012 NOx emissions of 61 tons/day is
  - About 75% of the total 2005 NOx emissions from all of the Haynesville counties in Texas
  - About 25% of the total NOx emissions from all source categories for the 5-County area

Assessing Ozone Impacts from the Haynesville Shale

- High ozone days in Northeast Texas often have stagnant winds
  - would tend to keep the Haynesville ozone precursor emissions in the region and available for ozone formation
- Evaluate the effect of the Haynesville Shale emissions on ozone levels in Northeast Texas with careful attention to their effect on the area's ozone attainment status.
  - NETAC is developing an ozone model for the year 2012 for the purposes of control strategy evaluation
  - Use model to quantify the impacts of development of the Haynesville Shale
  - Incorporate Haynesville Shale emission inventory into the ozone model and determine the contribution of the Haynesville Shale emissions to Northeast Texas ozone

Summary

- Results of this study suggest that the Haynesville Shale will contribute significant amounts of NOx to the regional inventory under the low and moderate scenarios, and will have an even larger impact under the aggressive development scenario
  - Wellhead compression emission calculations are likely underestimated, with the underestimate increasing in magnitude from 2010 to 2020
  - NOx emissions estimates provided above are likely to represent a lower bound, especially for the later years of the inventory