Development of an Emission Inventory for Natural Gas Exploration and Production in the Haynesville Shale and Evaluation of Ozone Impacts

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ABSTRACT

The Haynesville Shale is a rock formation that lies at depths of 10,000-13,000 feet below the surface in the vicinity of the Northeast Texas/Northwest Louisiana border near Shreveport. This formation is estimated to contain very large recoverable reserves of natural gas, and during the two years since the drilling of the first highly productive wells, has been the focus of intensive exploration and leasing activity. The development of natural gas resources within the Haynesville Shale is likely to be an important driver of local economic growth, but may also generate significant emissions of ozone precursors.

Based on well production data from state regulatory agencies and a review of the available literature, projections of future year Haynesville Shale natural gas production were derived for 2009-2020 for three scenarios corresponding to limited, moderate, and aggressive development. These production estimates were then used to develop an emission inventory for each of the three scenarios. Results for 2020 for the moderate scenario project that more than 120 tons/day of NOx will be emitted from Haynesville Shale sources.

Ozone modeling of the year 2012 using the CAMx model showed that significant 8-hour ozone impacts occurred within Northeast Texas and Northwest Louisiana as a result of development in the Haynesville Shale and that ozone increases from the Haynesville Shale emissions can affect regions outside Northeast Texas and Northwest Louisiana. This study evaluates only near-term ozone impacts, but the emission inventory projections indicate that Haynesville emissions may be expected to increase through 2020.

INTRODUCTION

The Haynesville Shale is an Upper Jurassic-era layer of sedimentary rock that is approximately 300 feet thick and lies at depths of 10,000-13,000 feet below the surface in Northeast Texas and Northwest Louisiana; it is sometimes referred to as the Bossier Shale in Texas. Exploratory wells drilled in the Haynesville Shale area in 2007-8 were determined to be highly productive, and the Haynesville Shale was touted as a significant new energy resource. For example, a 2008 report in the Wall Street Journal indicated that as many as 15,000 new wells were planned for the Haynesville Shale area. According to some estimates[1], the Haynesville Shale formation may contain as much as 250 trillion cubic feet (TCF) of recoverable gas, and several major energy companies have begun activities to develop this formation. Despite the recent economic downturn and the fall in price of natural gas since 2008, development of the Haynesville Shale has continued.

The development of the Haynesville Shale will require both significant exploration (i.e. drilling) activities and, as the field develops, construction of production and gathering/transmission infrastructure. Each of these activities will result in a significant population of equipment operating in the region, potentially contributing to emissions of ozone precursors. Because the formation lies deep beneath the earth's surface and requires significant rock fracturing to stimulate production, nitrogen oxide (NOx) emissions from drilling and well completion activities are expected to be high relative to development of shallow wells. In addition, volatile organic compound (VOC) emissions from completion activities and emissions from other initial activities such as fracturing and well pad construction will be relatively high. As the field develops, production and gathering/transmission infrastructure will be built, and related emissions will grow.

Given the potential level of activity in the Haynesville Shale, the development of the formation could result in significant emissions and impacts to local air quality. Emissions resulting from developing the Haynesville Shale would be released in a region that is within and/or frequently immediately upwind of potential ozone nonattainment areas[2]. Several counties within Northwest Louisiana and Northeast Texas as well as nearby Dallas-Fort Worth have been identified by the U.S. Environmental Protection Agency as areas that do not attain the 2008 ozone standard[3] of 75 ppb. In 2010, the EPA proposed a more stringent ozone standard[4] which further heightens the importance of understanding how development in the Haynesville Shale may impact future ozone air quality in the region.

In this study, an emission inventory of NOx, VOC and CO for Haynesville Shale natural gas exploration and production activities was developed. Well production data, the historical record of activity in the nearby Barnett Shale and other available literature were used to project future activity in the Haynesville Shale. Future year annual natural gas production for the years 2009-2020 was estimated for three scenarios corresponding to aggressive, moderate, and limited development of the Haynesville Shale. Constraints on available infrastructure and potential variability in well productivity and economics were also considered. Activity/equipment data from other oil and gas emission inventory studies were used to develop an emission inventory for ozone precursors for each of the three production scenarios.

Photochemical modeling of the year 2012 using these inventories showed that significant 8-hour ozone impacts occurred within Northeast Texas and Northwest Louisiana as a result of development in the Haynesville Shale and that ozone increases due to Haynesville Shale emissions can affect regions outside Northeast Texas and Northwest Louisiana. This study evaluates only near-term ozone impacts, but the emission inventory projections indicate that Haynesville emissions may be expected to increase through 2020.

EMISSION INVENTORY

Data Sources

Exploration and production in the Haynesville Shale have been going on for only three years; therefore peer-reviewed published information is extremely limited. Basic information, such as the geographic extent and recoverable reserves of the Haynesville Shale, are not yet known. The strategy in

developing estimates of future year activity and emissions was therefore to gather the best available information and cross-check among different sources of data where possible.

The Texas Commission on Environmental Quality (TCEQ), Texas Railroad Commission (RRC) and the Louisiana Department of Natural Resources (LDNR) were contacted regarding production and activity within the Haynesville Shale. The state agencies were able to provide some data, but recommended that the best source of estimates of future year activity and equipment use would be the producers active in the area. A survey was sent out to the producers identified on their company web pages, stockholder reports or venture capital firm reports as being major leaseholders in the Haynesville Shale as of March, 2009. Because so few wells had been drilled in the Haynesville Shale at that time, several producers felt that they did not yet have enough information to predict future year activity and production, and all of the producers declined to participate in the survey. We therefore assembled available data from the above state agencies and the available literature to determine the recoverable reserves as well as to derive future year activity projections. The emission inventory development was based on WRAP Phase III[5] and CENRAP oil and gas emission inventories[6,7].

Activity Projections

Based on well production data from state regulatory agencies and a review of the available literature, projections of future year Haynesville Shale natural gas production for 2009-2020 were derived for three scenarios corresponding to limited, moderate, and aggressive development[8]. Projections of future year activity were based on the number of new wells drilled each year. All scenarios began with the number of rigs operating in the Haynesville Shale as of March 2009. Three emissions scenarios were developed:

Low scenario:	Drill rig count held constant at March 2009
High scenario:	Drill rig count increases at 2001-2008 Barnett Shale growth rate with a cap at 200 rigs
Moderate:	50% of aggressive scenario

Emission Inventory

These production estimates were then used to develop an inventory of potential emissions from future natural gas exploration and production in the Haynesville Shale for all three scenarios. For exploration and production sources, emission rates were estimated based on data gathered in studies of other formations in the region[7,9]. For sources such gas plants and large compressor stations, emission rate estimates were based on 2004 emissions obtained from the LADEQ and 2005 emissions obtained from TCEQ scaled to future year Haynesville Shale formation production. 2004 emissions were used for Louisiana rather than 2005 to avoid using emissions data that are atypical due to the impact of Hurricane Katrina.

Estimates of 2012 NOx emissions in Northeast Texas and Northwest Louisiana due to development in the Haynesville Shale ranged from 61 tons/day in the limited development scenario to 82 tons/day in the moderate scenario to 140 tons/day in the aggressive scenario. Results for the moderate scenario indicate that by 2020, development in the Haynesville Shale results in more than 120 tons/day of additional NOx emitted in Northeast Texas and Northwest Louisiana. 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. 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. By 2020, NOx emissions from the Haynesville are larger than the 2005 NOx emission inventory for the entire 5-County Tyler-Longview-Marshall metropolitan area. These emissions increases are sufficiently large that it is necessary to evaluate their ozone impacts.

MODELING OZONE IMPACTS OF THE HAYNESVILLE SHALE

The Comprehensive Air-quality Model with extensions (CAMx)[10] was used to model the eastern half of the United States using nested 36, 12 and 4 km resolution grids with the 4 km grid located over the Haynesville Shale region. CAMx is a three-dimensional, chemical-transport grid model used for tropospheric ozone, aerosols, air toxics and related air-pollutants and is used for air-quality planning in Texas[11,12] and Louisiana[13]. CAMx was used here to estimate the near-term ozone impacts due to projected Haynesville Shale emissions during 2012[14].

The maximum differences in the daily maximum 8-hour ozone between the Haynesville Shale and a 2012 control run containing no Haynesville Shale emissions were calculated for the low and high scenarios. In the high scenario, increases greater than 15 ppb occur within Louisiana Haynesville Shale parishes due to the added Haynesville emissions, and increases greater than 5 ppb cover a broad region of northeast Texas and northwest Louisiana. Haynesville impacts extend northward into Oklahoma and Arkansas, and the westward into the Dallas-Fort Worth area. Other affected counties are McLennan, Travis, Hays, and Bexar Counties in Texas and the Baton Rouge area in Louisiana including Pointe Coupee, East and West Baton Rouge and Livingston Parishes. The pattern of impacts is similar but less intense in the low scenario. These results show that the impacts of development in the Haynesville Shale may extend well outside the immediate vicinity of the Haynesville Shale into other regions of Texas and Louisiana and affect areas that may not attain the new 2010 ozone standard.

CONCLUSIONS AND FUTURE WORK

The magnitude of projected emissions and modeled 8-hour ozone impacts indicate that development of the Haynesville Shale provides cause for concern about future ozone air quality in Texas and Louisiana. This analysis suggests that if the development of the Haynesville Shale proceeds at even a relatively slow pace, emissions from exploration and production activities will be sufficiently large that their potential impacts on ozone levels in Northeast Texas and Northwest Louisiana may affect the ozone attainment status of these areas. This study only evaluates near-term ozone impacts of development, but the emission inventory indicates that emissions may be expected to increase beyond 2012.

There is significant uncertainty associated with the emissions estimates presented here. The assumptions used in the development of the inventories – particularly the apparent limited need for wellhead compressors – indicate that these inventories could tend toward lower bound estimates. On the other hand, it is also possible that some source categories may be overestimated - for example, improvements in drilling technology could reduce future drilling times and therefore, NOx emissions associated with drilling. New controls or standards could also have a significant effect on future emissions, and only on-the-books regulations were applied to the Haynesville inventory.

The emission inventory was assembled during spring 2009, early in the development of the Haynesville when data were limited. Since then, the rapid pace of development in the Haynesville has continued, and additional data are available that can be used to refine the inventory. An extensive update of the data used to develop the original inventory is planned.

The geographic scope of the inventory will be expanded to include the new counties and parishes that have seen Haynesville development since the original study was performed in March 2009. The three future year scenarios will be revised to incorporate new data available regarding the actual pace of development. Recent data from the Texas Railroad Commission indicates that there were 238 producing Haynesville wells in Texas as of April 2010 with an additional 385 wells permitted. LDNR data indicates that there were 608 producing Haynesville wells in Louisiana as of August 2010, for a total of 846 producing wells in Texas and Louisiana as of approximately mid-2010. LDNR shows an additional 124 Haynesville wells being drilled and 499 Haynesville wells undergoing other operations such as fracing/completion. The present study estimated 783, 830, and 877 actively producing wells at the end of 2010 for the low, moderate, and aggressive scenarios, respectively. The actual mid-2010 well count suggests that the number of active wells predicted by even the aggressive scenario will likely be exceeded.

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KEY WORDS

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