

# Air Pollution Issues Associated

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Exploration and production of natural gas and oil are rapidly expanding across the country due to technological developments that have made extraction of previously untapped unconventional resources, such as shale gas, economically feasible. In part due to expansion of operations to locations where the industry has never been active, emissions of air pollutants, along with other potential environmental and public health impacts, have come under increasing scrutiny.

An overview of environmental and public health risks and the need for improved regulation and industry practices is presented in a recent report of the National Petroleum Council.<sup>1</sup> Although some efforts are underway to improve our knowledge about air emissions from the oil and gas industry, there remains much uncertainty about the actual amount released. Notwithstanding this uncertainty, studies suggest that emissions from the oil and gas industry could be comparable to other major source categories in some concentrated areas. Moreover, while smokestack emissions of greenhouse gases (GHGs) from coal-fired power plants are substantially higher than from natural gas (NG)-fired plants, questions have been raised about how the upstream emissions associated with the extraction, processing, and transportation of each fuel affect the relative climate footprint of NG when the complete fuel cycles are considered.

This article reviews key air pollution concerns and air policy considerations associated with the gas and oil industries.

## Sources of Air Emissions

Leaks and routine venting during the extraction, processing, and transportation of NG result in emissions of GHGs and, depending on the local composition of unprocessed gas, other pollutants that contribute to locally- and regionally-elevated air pollution that may threaten public health. There are numerous individual components used throughout NG and oil production systems that are prone to leaks, including compressors, valves, pumps, flanges, gauges, and pipe connectors.

In addition to unintentional leaks, a number of sources intentionally vent gas. For example, one technology used throughout NG systems is pneumatic valves, which operate on pressurized NG and by design bleed small quantities of gas during normal operation. Additionally, gas is often vented from storage tanks, dehydrators, depressurization of equipment before maintenance, and wells after hydraulic fracturing or when accumulated liquids are removed. Within the oil sector, nearly all methane (CH<sub>4</sub>) emissions come from production fields in the form of venting from oil wells, storage tanks, and processing equipment.<sup>2</sup>

Engines and other combustion sources associated with the upstream and midstream segments of the

# with Natural Gas and Oil Operations

NG and oil industry also produce emissions that can affect local and regional air quality.

## Air Pollution Concerns

The fugitive and vented emissions from NG operations consist predominantly of CH<sub>4</sub>, a potent GHG, but often also include organic compounds that contribute to the formation of ground-level ozone (smog), as well as hazardous air pollutants like benzene.

## Methane

Methane is the principal component of NG and is a potent GHG with a warming potential 25 times that of carbon dioxide (CO<sub>2</sub>) over the long term (100-year time horizon) and 72 times over the short term (20-year time horizon). [Note: The values of 25 and 72 are CH<sub>4</sub>'s global warming potential (GWP); GWP is a commonly used concept to compare the radiative forcing of GHGs relative to that of CO<sub>2</sub>. The Intergovernmental Panel on Climate Change (IPCC) typically uses a 100-year time horizon for the calculation of GWP; but a 20-year horizon is sometimes used.]

In addition to its climate impacts, CH<sub>4</sub> contributes to higher global background levels of ozone pollution.<sup>3-5</sup> Natural gas and oil operations are the largest source of U.S. CH<sub>4</sub> emissions. The U.S. Environmental Protection Agency's (EPA) estimate of the amount of CH<sub>4</sub> released in 2009 because of leaks and venting in the NG network between production wells and the local distribution network is 10.5 million metric tons (MMT);<sup>6</sup> this corresponds to just over 2% of gross U.S. NG production. A

recent paper based on a pilot study using innovative air sampling approaches concluded that NG leakage in the Denver–Julesburg Basin might be even higher than EPA's estimate; although the measurements provide only one snapshot of what is happening in NG production fields, 4% was the central estimate reported.<sup>7</sup> This discrepancy points to the need for more direct measurement of emissions, as discussed later.

## Ozone Precursors

Natural gas and oil industry activities also emit Volatile Organic Compounds (VOCs) and oxides of nitrogen (NO<sub>x</sub>), which are precursors to ground-level ozone. In areas of concentrated activity, the emissions can be substantial.

For example, NG and oil activities were the single largest source of ozone precursor pollutants in Colorado in 2008.<sup>9</sup> The Texas Commission on Environmental Quality has reported that storage tanks used in the exploration and production of NG and oil are the single largest source of VOCs in Texas.<sup>10</sup> In the Barnett Shale of North Texas, the combined VOC and NO<sub>x</sub> emissions from NG and oil production have been estimated to be comparable to those from the roughly 4 million cars and trucks in the adjoining Dallas Fort-Worth metro area.<sup>11</sup>

The air quality impacts of these emissions vary based on local conditions, but they can be important, especially in rural areas.<sup>12</sup> Wintertime ozone levels in excess of the nation's health-based air quality standards have been recorded in remote

parts of Wyoming and Utah, where little industrial activity other than NG and oil production occurs. Air modeling for the Haynesville Shale projects an increase in ozone levels near NG drilling and production and in adjacent regions due to ozone transport.<sup>13</sup>

### **Hazardous Air Pollutants**

Hazardous air pollutants (HAPs) from NG and oil operations include hydrogen sulfide and certain hydrocarbons such as benzene, a known human carcinogen. Formaldehyde is a HAP found in the exhaust of compressor engines. Elevated levels of benzene have been detected near NG production sites in Texas<sup>14</sup> and Colorado.<sup>15,16</sup> In these cases, ambient concentrations appear to be variable and lower than health-based screening levels. Although little work has been done to characterize the health effects of such exposures, media reports anecdotally suggest growing complaints of health concerns (e.g., respiratory and skin irritation, neurological problems, dizziness, and headaches) by people living near NG operations.<sup>17,18</sup>

### **Policy Considerations**

#### **Methane Emissions**

Although NG burns cleaner than coal and petroleum-based fuels, uncombusted CH<sub>4</sub> leaked along the NG supply chain erases some of the carbon advantage that NG has over other fossil fuels at the point of combustion. At some point, NG leakage can be large enough to make NG use worse overall for climate for some period of time. A number of scientific papers on the climatic implications of NG production and use relative to other fuels have been published in the past 18 months.<sup>19-24</sup> These papers have inadvertently figured into a growing sense of confusion due to sometimes divergent conclusions and approaches.

There are two main differences among these papers. The first is how they compare the time-dependent effects on climate of CH<sub>4</sub> and CO<sub>2</sub>, the principal contributor to man-made climate change. CH<sub>4</sub> is a much more potent GHG than CO<sub>2</sub>, molecule for molecule, but it is removed from the atmosphere much more quickly; these competing effects complicate the comparison of their climate impacts. The second, more fundamental difference is the choice of CH<sub>4</sub> leakage assumed for the NG supply. This choice is challenging due to the limited empirical data available on the actual amount of CH<sub>4</sub> released to the atmosphere across the NG supply chain, including during production, processing, and delivery to customers.

A recent paper proposed a more transparent analytical approach that reveals the inherent climatic trade-offs of different policy and investment choices involving NG for electricity and transportation.<sup>25</sup> Using the best available data from EPA on CH<sub>4</sub> leakage in the NG supply and similar data for other fuel cycles, this paper concluded that new NG combined cycle plants are beneficial on all time frames for climate compared to new coal plants, as long as leakage stays under 3.2%. On the other hand, for NG vehicles to produce climate benefits on all time frames, well-to-wheels CH<sub>4</sub> leakage would have to be reduced to 1.0–1.6%.<sup>26</sup>

Because of the pivotal role that NG leakage plays in determining whether fuel switching scenarios involving NG are better or worse for the climate, it is critical that definitive, scientifically rigorous measurements of actual emissions be made. While NG operators will begin reporting CH<sub>4</sub> emissions to EPA later this year, it is unclear how accurate these data will be, especially during the first year or two of reporting because companies have been allowed a grace period to use less rigorous estimation methods than technically required in EPA's rules.

#### **VOC and HAP Emissions**

On April 17, 2012, EPA adopted final rules establishing—for the first time—emission standards for NG well sites and strengthening existing standards for gas processing plants and pipeline compressors.<sup>27</sup> While EPA's rules represent an important step forward in reducing pollution from hydraulically fractured gas wells and discrete equipment types, gaps remain. Additional standards are needed to reduce VOC and HAP emissions from other

### **How Important Is CH<sub>4</sub> Leakage from NG Systems?**

Over a 100-year time horizon, EPA's estimate that NG systems emitted 10.5 MMT of CH<sub>4</sub> in 2009 has the same effect on climate as 263 MMT of CO<sub>2</sub>. For comparison, 263 MMT of CO<sub>2</sub> is the same amount of CO<sub>2</sub> that is released annually by 62 coal-fired power plants or 52 million passenger vehicles.<sup>8</sup> The cumulative climate "influence" (more specifically, the cumulative radiative forcing) of this CH<sub>4</sub> leakage is 3.9% of the total from all U.S. GHG emissions over a 100-year time horizon. Considering a 20-year time-horizon, which more fully captures the short-term climate influence of CH<sub>4</sub>, NG leakage accounts for 9.1% of the total climate influence from all U.S. GHG emissions.



sources, such as wells that co-produce oil and NG and certain existing sources, as are standards that directly limit CH<sub>4</sub>.

EPA's rules will reduce air pollution through proven and highly cost-effective air pollution controls; they will standardize many common sense practices and technologies already implemented in states such as Colorado and Wyoming, and that are already being used by many NG companies throughout the country. The rules will also prevent the needless waste of a valuable domestic energy source by preventing leaks and venting of NG. Though EPA's new rules do not directly regulate CH<sub>4</sub>, it will be reduced as a co-benefit of the required controls. Consequently, EPA's rules will lead to some improvement in the climate footprint of NG by

reducing CH<sub>4</sub> leakage, although more must be done to reduce CH<sub>4</sub> leaks directly.

## Conclusion

Achieving and maintaining low emissions of air pollutants from NG and oil operations is crucial to minimizing adverse health impacts in adjacent communities and maximizing the climate benefits of NG fuel switching pathways. Significant progress (surpassing that expected through implementation of EPA's new air emissions rules) appears possible given the economic benefits of capturing and selling lost NG and the availability of proven technologies.<sup>28</sup> Additionally, better emissions data are needed to confidently evaluate the risks of NG and oil operations to health and climate and to effectively manage operations. **em**



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