**Natural Gas: An Air Quality & Climate Change Solution**

U.S. greenhouse gas (GHG) emissions have declined to the lowest level since 1994, in part because of increased natural gas electricity generation replacing coal generation.[1] Natural gas emits about half the carbon dioxide ($CO_2$) of coal when burned for electricity. Whereas coal once produced almost 57% of U.S. annual electricity generation in the mid-1980s, it was down to 39% in 2013, and natural gas generation has increased to almost 28% of annual generation from a low of 9% in 1986.[2] In addition to lower carbon emissions, natural gas burns more cleanly than coal and does not produce harmful soot, mercury and sulfur emissions. Burning natural gas for electricity generation improves air quality and helps cities become compliant with tour nation's air quality standards.

While increased natural gas use offers meaningful solutions for climate change, many have raised concerns that methane leakage from natural gas production and distribution could erase any climate benefits. Methane emissions from natural gas production are a known source of GHGs, but when considered over the full lifecycle from production to end use, the GHG footprint of natural gas is much less than coal. Overall, GHG emissions from the oil and natural gas industry are about ten times less than the largest source, power plants.[3]

In an attempt to justify more regulation of the natural gas industry, environmental advocates and regulatory agencies have claimed methane harms public health. Methane itself is not harmful to breath; if it were, we could not use natural gas stoves to cook, and we would not last long when the heat came on in our homes. Because methane poses no direct public health risk, methane is not a hazardous air pollutant (HAP) nor a criteria pollutant in the Clean Air Act. Methane is a component of the air, just like $CO_2$, oxygen, nitrogen, and other gases. The only direct danger of methane is its flammability when contained at high concentrations, similar to the dangers of other gases we breathe every day.

Methane is a greenhouse gas that has been linked to indirect long-term and largely unknown public health impacts of climate change. The large uncertainties associated with regional climate projections and the many confounding factors that impact public health make these links tenuous at best, and regulation of one source of methane cannot be based on such weak connections when methane is also emitted naturally and by other industries. When natural gas is used to produce electricity, boil water or for whatever use, the methane is consumed and $CO_2$, water vapor and other minor byproducts are emitted.

When public health arguments fail, advocates for regulation often claim methane leads to poor air quality by causing ozone.[4] The overwhelming majority of chemicals that cause ozone are volatile organic compounds (VOCs) and nitrous oxides ($NO_x$), not methane. While methane can participate in the reactions that form ozone, it reacts so slowly that its contribution is

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[1] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, EPA, February, 2014
[2] Electricity Generation from Monthly Energy Review, EIA, June 25, 2014
[3] *Greenhouse Gas Reporting for Power Plants*, EPA, 2013
[4] See for example Colorado Air Quality Control Commission Regulation Number 7, CO Department of Public Health and Environment, February 23, 2014

overwhelmed by VOCs and $NO_x$. Significant reductions to ozone cannot be gained by regulating methane emissions, and the use of ozone to justify methane regulations is simply not scientifically or legally supportable.

**Industry Continues To Reduce Emissions**

While the controversy over methane emissions continues, industry consistently works to reduce methane emissions by developing new technologies and practices. Figure 1 shows the annual and cumulative methane emissions reductions through new technologies and application of best practices. For example, industry developed Reduced Emissions Completions (RECs) or "green completions" technologies to capture methane and other gases during the well completion process. It is also developing smart technologies and methods for reducing emissions during well liquid unloading. Companies are switching from high-bleed to low-bleed pneumatic devices to reduce the amount of methane that escapes, and they are installing controls on storage tanks. The continued modernization of industry practice and technology ensures natural gas will continue to provide a meaningful solution for reducing greenhouse gas emissions into the future.

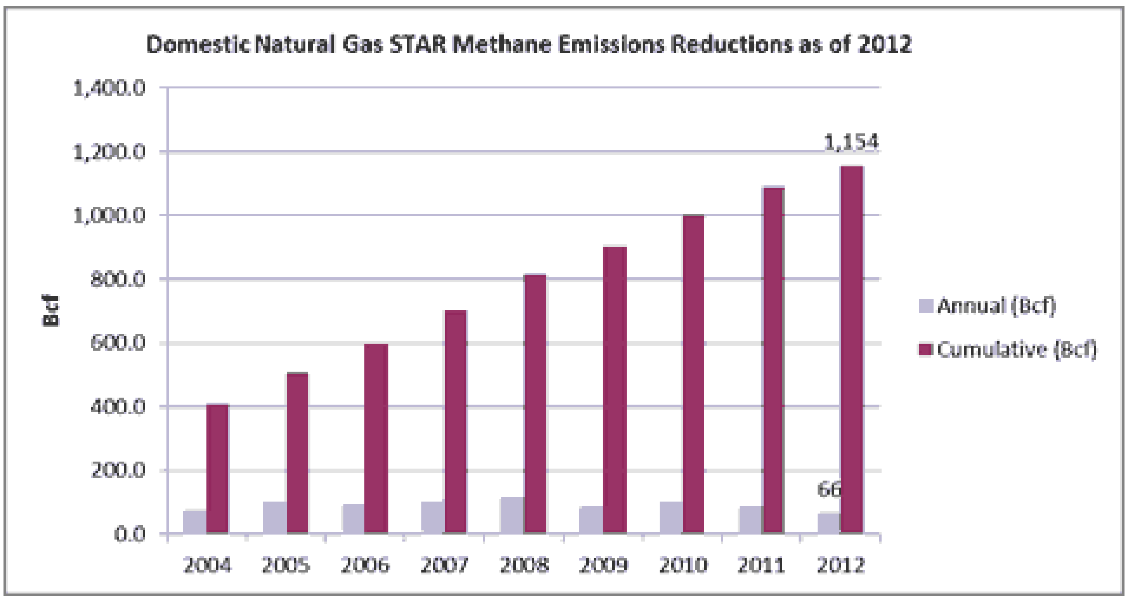


***Figure 1.*** *From EPA's Natural Gas STAR Program, this graph shows annual and cumulative methane emissions reductions from the natural gas industry.*

In fact, industry has delivered significant GHG reductions through voluntary means. Industry reduced methane emissions by 40% between 2006 and 2012 without federal regulation, and agriculture is now the largest source of methane.[5] Figure 2 shows the main contributors to methane emissions in the U.S. Natural gas and petroleum systems account for only 3.5% of all U.S. GHG emissions.

[5] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012, EPA, February, 2014

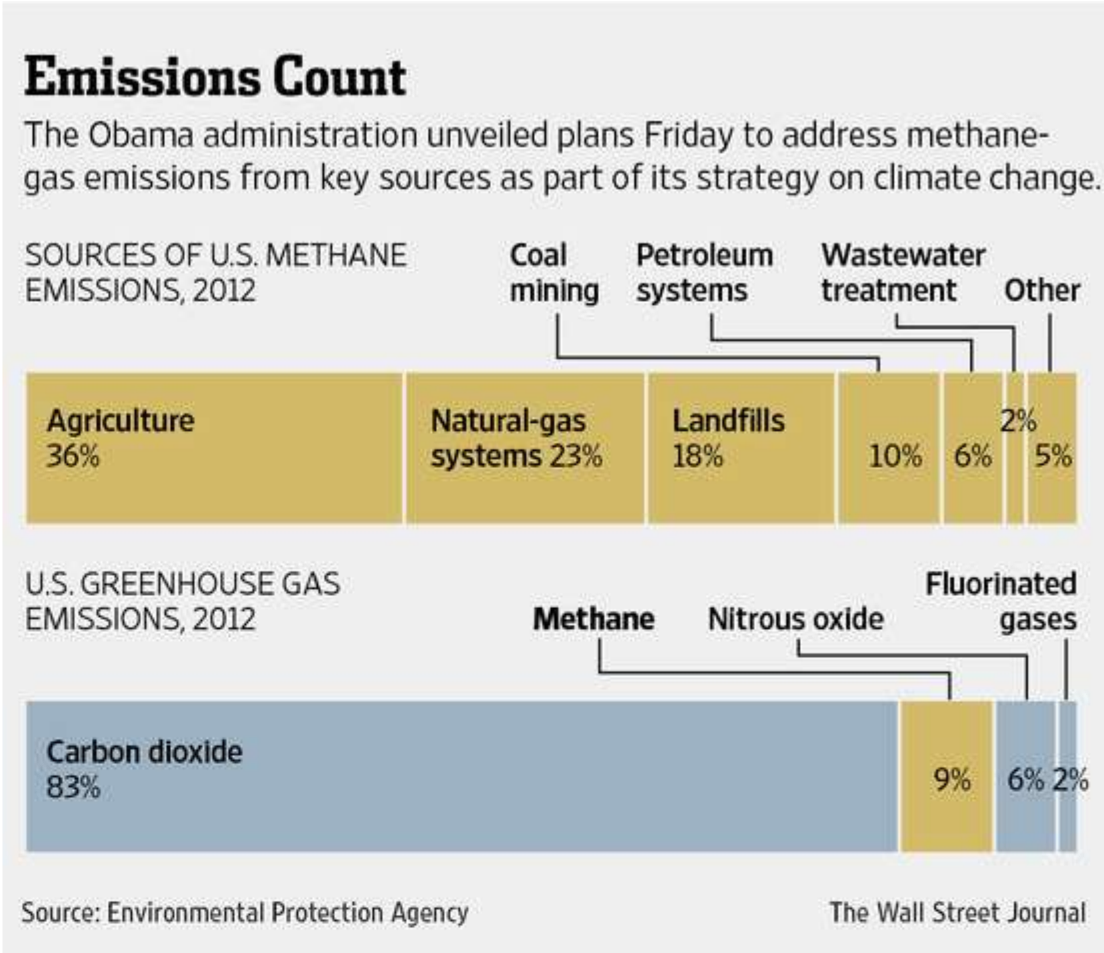


***Figure 2.*** *From the Wall Street Journal, this figure illustrates the sources of methane emissions from EPA's Annual GHG Inventory for 2012.*

**Measuring Methane Emissions**

Methane emissions from natural gas systems have recently been analyzed in several ways, and all of the studies appear to give a different answer because they are calculating different parameters and using different assumptions. Developing emissions inventories can be difficult as they are dependent upon activity data from industry, and emissions factors can be troublesome to calculate. But given the sheer number of oil and natural gas sites and equipment across the U.S., determining emissions factors from samples is one of the only ways to get a picture of total emissions.

Examining the lifecycle benefits of natural gas use for electricity generation compared to coal is one of the best ways to put methane emissions in context. A study by the National Energy Technology Laboratory (NETL) found that based on baseload electricity production, GHG emissions are 42-53% less for natural gas than for coal.[6] The two main reasons for this benefit

[6] Life cycle greenhouse has inventory of natural gas extraction, delivery and electricity production, US Dept. of Energy, DOE/NETL-2011/1522, Oct. 24, 2011.

are the lower carbon intensity of natural gas and the higher efficiency of natural gas power generators.

The NETL study points out that GHG comparisons between coal and natural gas must be made based on providing an equivalent end-use service, for example one megawatt-hour (Mwh) of electricity. Not all life cycle studies compare common end-uses, which makes them difficult to compare and might render their results inherently flawed. Figure 3 illustrates the importance of considering the entire lifecycle of a given fuel. Emissions from burning the fuel (green bars), rather than production and distribution of the fuel (blue and red bars) are the largest fraction of the total lifecycle emissions. Focusing just on methane emissions on the production end can cause regulators to lose site of the larger climate change benefit that natural gas provides.

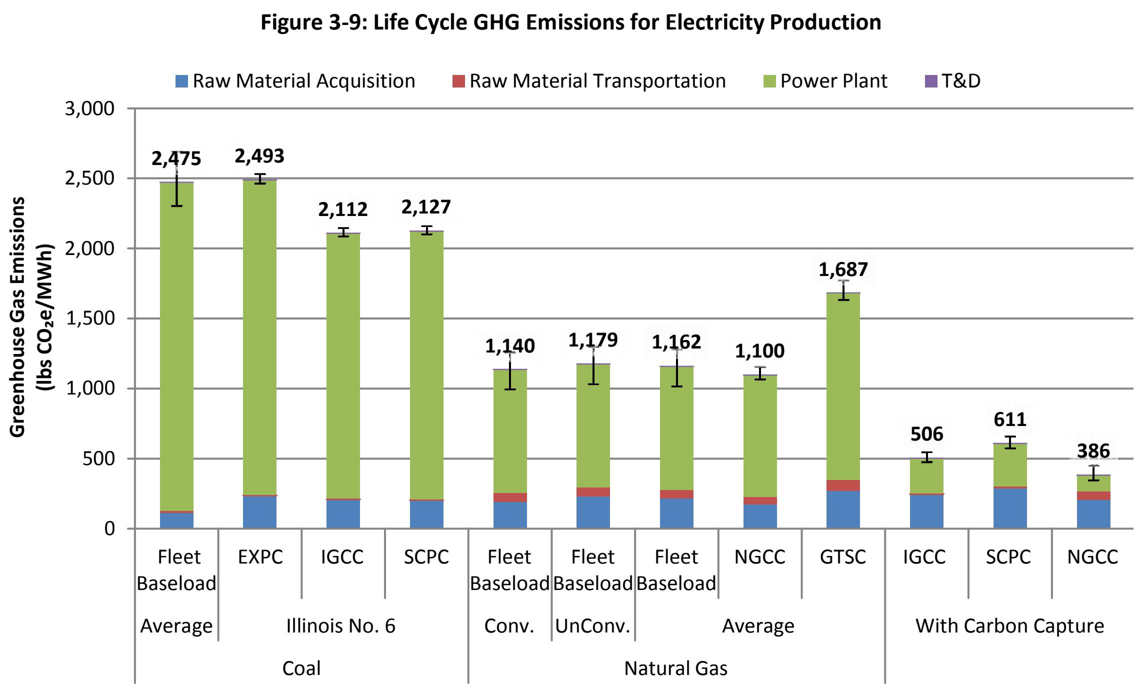


***Figure 3.*** *Copied from NETL (2011) figure 3-9, the lifecycle greenhouse gas emissions for electricity produced from various types of coal and natural gas generation plants. Note most emissions come from combustion at the power plant.*

Many of the recent life cycle comparisons to coal have addressed only the upstream emissions of methane from natural gas or have even focused on emissions from specific processes, usually hydraulic fracturing (HF). In a discredited study, Howarth and others made waves when they found that natural gas was worse for the climate than coal.[7] However, the researchers relied on questionable assumptions about natural gas industry practice, focused on short timeframes,

[7] Methane and greenhouse-gas footprint of natural gas from shale formations, RW Howarth, R Santoro, and A Ingreffea, *Climatic Change,* DOI: 10.1007/s105484-011-0061-5, 2011.

which is inappropriate for climate considerations, and failed to compare equivalent end-uses. Despite several studies that discredited the Howarth study, activists continue to use it. [8, 9, 10, 11]

Recent life cycle studies have given methane emissions rates anywhere from less than 1% to more than 6% of production. Because there are different techniques to calculate methane, whether through bottom-up inventories or top-down, direct measurement or estimation from equipment inventories, different scientists come up with different numbers. With so many analyses giving different numbers, scientists at the National Renewable Energy Lab used a method called harmonization to compare eight different life cycle analyses of natural gas system methane emissions.[12] They found GHG emissions for electricity generation are similar for shale gas and conventional gas and that both are about half those of coal.

The EPA and other organizations calculate bottom up emissions inventories and emissions factors for each activity used to produce natural gas. EPA has not updated many of their emissions factors to accurately reflect improved industry practices since the early 1990s, but a joint study by the University of Texas, EDF and industry is underway to improve current emission factors. The first part of the study found that methane leakage from natural gas exploration and production was similar to the 1.5% of production that EPA reports, and that methane leakage from hydraulic fracturing was much lower than originally thought.[13] Such a low leakage rate means that natural gas retains its greenhouse gas benefits.

Because there is no practical way to continuously measure all methane emissions, scientists and regulators would like to verify emissions inventories with independent measurements of the atmosphere. Recently, atmospheric scientists have begun directly measuring methane concentrations in oil and gas development areas. A NOAA study measured methane in and around the Denver-Julesburg (DJ) Basin in Colorado's Front Range using a mobile lab set-up in a van and an instrumented tower. [14] They calculated 2.3-7.7% of annual produced methane is lost by venting in the DJ Basin in 2008, but this result was not without controversy. They assume all oil and natural gas methane emissions come from just two sources, tanks and fugitive emissions, and they use a very small number of samples to calculate emissions from these sources. In response to the NOAA study, Levi was able to refine their assumptions and further constrain

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[8] A commentary on "Methane and greenhouse-gas footprint of natural gas from shale formations", LM Cathless, III, L Brown, M Taam and A Hunter, *Climatic Change,* DOI: 10.1007/s10584-011-0333-0, 2012.

[9] Greater focus needed on methane leakage from natural gas infrastructure, Alvarez, RA and 4 others, *Proc. Nat. Acad. Sci.,* doi: 10.1073/pnas.1202407109, 2012.

[10] Shale gas production: potential and actual greenhouse gas emissions, F O'Sullivan and S Paltsev, *Environmental Research Letters,* **7,** 044030, 2012.

[11] Climate consequences of natural gas as a bridge fuel, Levi, MA, *Clim. Change,* DOI: 10.1007/s10584-012-0658-3, 2013a.

[12] Harmonization of initial estimates of shale gas life cycle greenhouse gas emissions for electric power generation, G. A. Heath and 3 others, *Proc. Nat. Acad. Sci.,* doi: 10.1073/pnas.1309334111.

[13] Measurements of methane emission at natural gas production sites in the United States, D.T. Allen and others, *Proceeding of the Nation Academy of Sciences*, October 29, 2013.

[14] Hydrocarbon emissions characterization in the Colorado Front Range – A pilot study, G Petron and 29 others, *Journal of Geophysical Research,* **117,** doi:10.1029/2011JD016360, 2012.

methane emissions. In doing so, he calculates emission rates closer to bottom up inventories, 1-2% of production.[15]

There are several other groups measuring ambient methane concentrations over natural gas basins, including the NOAA group in Utah, Purdue University in the Marcellus and Williston Basins, and Carnegie Mellon. These atmospheric measurements typically take place over several hours on one or two days, but emissions from natural gas operations are not steady through time and space. Emissions vary a great deal from exploration to production and throughout the life of a producing well. Therefore, one cannot simply take measurements from a few days and extrapolate them to an entire year and divide by annual production to get the leakage rate.

The three types of studies described here can give us information about methane emissions from oil and natural gas production, but comparisons between them must be undertaken with caution. Most credible studies show methane emissions to be 1-2% of production, currently, and industry continues to find new ways to reduce emissions even more.

**Regulation**

Methane is not considered a hazardous air pollutant (HAP) nor criteria pollutant under the Clean Air Act. Because it is a GHG, however, industries are required to report their GHG emissions under EPA rules. For now, methane from oil and natural gas systems is not officially regulated by EPA, but is still controlled under the New Source Performance Standard (NSPS)/National Emissions Standards for HAPS (NESHAP) Rule for Oil and Natural Gas for VOC emissions. Methane is not a VOC, but its emissions will be reduced as VOCs are controlled.

EPA is using the rule to implement back-door regulation of GHG emissions. The Clean Air Act enables EPA to issue NSPS/NESHAP regulations for purposes of controlling criteria pollutants and HAPs, yet in the rule justification EPA cannot quantify the benefits of either. The environmental benefits EPA is claiming result exclusively from methane capture, a greenhouse gas which is neither a criteria pollutant nor a HAP. EPA takes credit for the methane companies have been capturing for years in the regular course of operations and in the absence of federal regulation, EPA disingenuously claims that the rule will provide an annual economic benefit of $45 million. Only by overestimating methane emissions by 200% is EPA able to arrive at its economic benefit number.

EPA has also written five white papers on methane emissions from oil and natural gas production as part of their amendment process for the NSPS/NESHAP rule. It is not clear whether EPA intends to add methane to the rule through amendments, which would not follow Administrative Procedures Act requirements, or if they plan to proposed a completely new rule. No matter which path they choose, EPA will be adding more onerous regulation on an industry that has been reducing methane emissions without EPA mandate for many years.

[15] Comment on "Hydrocarbon emissions characterization in the Colorado Front Range – A pilot study," MA Levi, *Journal of Geophysical Research,* **117,** DOI: 10.1029/2012JD017686, 2012.