NGVAMERICA
Natural Gas Vehicles for America

Response to Science Magazine Article on Methane Leakage

Introduction

A study reported in the journal *Science* ("Methane Leaks from North American Natural Gas Systems", February 14, 2014, Vol. 343) concludes that "Methane emissions from U.S. and Canadian natural gas systems ***appear*** larger than official estimates" (emphasis added). From that, the paper concludes that the greenhouse gas (GHG) emission advantage of vehicles powered by natural gas compared to gasoline may be less than indicated in other publications and studies, and that the GHG emissions of natural gas vehicles may even be greater than those of diesel vehicles.

These conclusions about natural gas vehicles are not supported by this study since:

- This is NOT a study of the GHG emissions attributable to natural gas vehicles. The natural gas vehicle conclusion almost appears as an afterthought.
- The one study cited by the authors as support for the conclusion about natural gas vehicles is not valid for that purpose.
- If the authors' conclusion about increased methane from petroleum and natural gas systems is used, methane emissions attributable to diesel vehicles also would be greater than the authors assumed.
- The study is not based on any new data — it is a literature review, i.e., a study of existing studies with widely varying methodologies, datasets, and conclusions.
- The authors repeatedly acknowledge the significant uncertainty in the studies, and the need for additional science, which fundamentally undermine their proposed conclusions.
- The study arbitrarily assumes that studies using "top-down" methodology, which shows more total methane in the atmosphere, are more accurate and valid than ones using rigorous "bottom-up" methodology (which shows less), and, therefore, assumes human-caused methane emissions (including from petroleum and natural gas systems) are the cause of the discrepancy.

Background

Methane (CH_4), the primary component of natural gas, is a GHG (about 25 times as effective a GHG as carbon dioxide — although with a far shorter life in the atmosphere), and methane is emitted from the natural gas system from production through processing and through distribution. The methane emitted from petroleum and natural gas systems account for about 1.3 percent of all GHGs emitted into the

atmosphere.[1] Any analysis of the GHG impact of using natural gas in an application must take into both the methane emitted by the application and these upstream methane emissions. According to EPA's most recent analysis of methane emissions, approximately 1.4 percent of natural gas that is produced in the U.S. is emitted to the atmosphere during the various processes involved in extracting, processing, and distributing the natural gas to end-use customers.[2] At these levels, natural gas vehicles provide about a 13–21 percent reduction in total greenhouse gas emissions (well-to-wheels) compared to new diesel and gasoline vehicles.[3] Reductions achieved when replacing older petroleum fueled vehicles are even greater. The paper published in *Science* concludes that the latest EPA study underestimates the amount of leakage from the natural gas system. Therefore, the paper concludes that the GHG emissions of natural gas vehicles may even be greater than those of diesel vehicles. The evidence presented in the paper does not support that conclusion. Here's why:

- **This is NOT a study of the GHG emissions attributable to natural gas vehicles.** There is only one mention of natural gas vehicles in the paper, and that is when they conclude *"… climate benefits from vehicle fuel substitution are uncertain (gasoline, light duty) or improbable (diesel, heavy-duty) …"*

- **The one study cited by the authors as support for the conclusion about natural gas vehicles is not valid for this purpose.** As pointed out in a recent blog post by Michael Levi, a Senior Fellow at the Council on Foreign Relations[4],
    - The study cited was a Proceedings of the National Academy of Sciences' paper from 2012 that based its assumption about the relative fuel efficiency of natural gas versus diesel-fueled vehicles based only on urban buses — one of the least efficient applications using natural gas.
    - Natural gas engine efficiencies vary greatly, depending on the size of vehicle, type of engine, and how it is driven, so drawing a conclusion from a single application as the authors of the *Science* paper appear to have done, heavily skews the results, and produces an invalid result.

[1] According to EPA (http://epa.gov/climatechange/ghgemissions/gases/ch4.html), of the total greenhouse gases emitted into the atmosphere, methane accounts for only 9 percent (with the greater GHG potential factored in). About 40 percent of all methane emitted is from natural sources, e.g., termites, wetlands). Of the 60 percent that is result of human activity, 30 percent is from petroleum and gas systems. In other words, 1.3 percent (8.89%*60%*24.6%) of all greenhouse gases in the atmosphere is attributable to methane from petroleum and natural gas systems.

[2] At $4 per thousand cubic feet, this amount of natural gas would have a market value of about $1.6 billion per year.

[3] Figures based on modeling using Argonne National Laboratory's AFleet Tool (http://greet.es.anl.gov/afleet). Twenty-one percent reduction is based on heavy-duty natural gas truck using a dual-fuel engine where efficiency is assumed to be equivalent to comparable diesel engine.

[4] http://blogs.cfr.org/levi/2014/02/14/is-natural-gas-worse-for-climate-change-than-diesel-fuel/

Many other, more appropriate studies that the authors could have selected conclude that natural gas has a significant GHG advantage over diesel-powered vehicles.

- **If the authors' conclusion about increased methane from petroleum and natural gas systems is used, methane emissions attributable to diesel vehicles also would be greater than the authors assumed.** The study on which the authors rely for their vehicle comparison assumes a level of upstream GHG emissions for diesel fuel, gasoline and natural gas vehicles. If, as the auditors conclude, more methane is emitted from petroleum and natural gas systems, both the emissions from natural gas *and* diesel vehicles must be increased for a valid comparison. It does not appear that the authors adjusted methane emissions for gasoline and diesel fuel.

- **The paper is NOT based on any new data or research.** It is a meta-study, i.e., a study of the data and conclusions from 200 other studies. None of those studies are comprehensive or definitive and the authors did not attempt to evaluate the methods used in or the validity of those studies. Some of those studies have been adequately peer-reviewed; some have not. Some of those studies include generally acknowledged observations; others include assumptions that have been criticized. Some of those studies suggest that the leakage rate from the natural gas system may be less than EPA's latest study; some suggest that it may be greater. Given the varying data collection methodologies, analytical approaches, conclusions and validity of the studies, drawing a conclusion about something as specific as the GHG benefits of natural gas vehicles seems questionable.

- **The authors arbitrarily assume that studies using "top-down" methodology are more accurate and valid than ones using rigorous "bottom-up" methodology and, in doing so, fail to adequately assess the impact of natural (non-human) methane emissions.** The key question that this study explores is why "top-down" measurements show more methane in the atmosphere than would be predicted by site-specific, "bottom up" studies. The paper states: *"Across years, scales, and methods, atmospheric studies systematically find larger CH4 emissions than predicted by inventories."* The authors appear to assume that the top-down studies are accurate and, therefore, that the bottom-up studies, such as the latest study from EPA, must be underestimating the emissions *from human activity*. There are a wide range of possible non-human activity explanations for this discrepancy that are more reasonable than attributing it to natural gas systems. For example, the scientific literature on

methane hydrate formations suggests that, as the earth's temperature increases, the amount of methane release from these formations increases.[5] The paper states: *"Evidence from regional studies suggests that CH4 emissions with fossil signatures are larger than expected (3, 6, 7, 9, 11), whereas national-scale evidence suggests a mix of biogenic and fossil sources (6). Atmospheric studies that control for biogenic CH4 sources (1, 2, 7) are dependent on biogenic source estimation methods that also have high uncertainties (6). Natural geologic seeps could confound attribution."*

- **The authors themselves recognize the inadequacy of the studies they are using by carefully including many caveats in the paper**. Below are some example:
    - *"… emissions ratios for bottom-up studies are more scattered than those observed in atmospheric studies."* Meaning studies that actually measure methane emissions at the source vary greatly. Which are accurate and which are not? That's not a question with which the authors dealt.
    - *"Regional and multistate studies focusing on NG-producing (1– 3, 9) and NG-consuming regions (2, 7, 10– 12) find larger excess CH4 emissions than national-scale studies. This may be due to averaging effects of continental-scale atmospheric processes, to regional atmospheric studies focusing on areas with other air quality problems (1,3), or simply to methodological variation."* In other words, the authors do not know why the studies differ, and which ones accurately measure emissions and which do not.
    - *"Regional studies cover 0.5 to 5% of NG production consumption with dense measurements, although often limited to short-duration sampling "campaigns" (3, 7); national studies cover wide areas with limited sample density."* In other words, the authors question whether the results of these studies are accurate, i.e., whether they match reality.
    - *"… activity and device counts used in inventories are contradictory, incomplete, and of unknown representativeness."*
    - *"Alkane fingerprints may allow attribution to oil-associated NG (9), although NG processing changes gas composition, which may complicate efforts to pinpoint leakage sources"*
    - *"Without spatial isolation, sector attribution can require assumptions about gas composition that introduce significant uncertainty"*

[5] Methane hydrates are a solid compounds in which a large amount of methane is trapped within a crystal structure of water, forming a solid similar to ice. Significant deposits of methane hydrates have been found under sediments on the ocean floors of earth. It is estimated there is twice as much energy in the form of methane in hydrates than in all the oil, coal and natural gas in the world combined. As the earth continues to warm, more of the methane hydrates are melting, releasing methane into the atmosphere. Geologists don't even know where all the earth's hydrate formation are — much less how much of the methane is seeping from them.

- *"In general, the wide ranges in the second chart suggest a poor understanding of sources of excess CH4 and point to areas where improved science would reduce uncertainty."*

- **Natural gas systems are usually lumped together with petroleum systems.** Including the methane emissions from petroleum production in estimates of natural gas production exaggerates the full-cycle (well-to-wheels) of natural gas vehicles. The authors recognize this problem when they state: *"… climate benefits from vehicle fuel substitution are uncertain (gasoline, light duty) or improbable (diesel, heavy-duty) (28).* ***These conclusions may undercount benefits of NG, as both EPA GHGI methods and many regionally focused top-down studies attribute CH4 emissions from coproducing NG systems to the NG sector, rather than to a mixture of oil and NG sources****"* (emphasis added).

Conclusion

After reviewing this paper, it is clear that the findings of the paper do *not* support the conclusion that using diesel fuel in vehicles produces less GHGs than using natural gas.

At the end of the paper, the authors state: "*If natural gas is to be a "bridge" to a more sustainable energy future, it is a bridge that must be traversed carefully: Diligence will be required to ensure that leakage rates are low enough to achieve sustainability goals …"* Most people inside and outside the natural gas industry would agree. That effort is already well underway. As the *Washington Post* pointed out in its recent editorial, the natural gas industry is making significant strides to capture methane that might currently be leaking.[6]

Increasing the use of natural gas in cars, trucks, buses, locomotives, and marine applications reduces imports of foreign oil, increases jobs here at home, reduces the level of urban emissions — *and* reduces GHGs. It would be a major policy mistake to hamper the switch to natural gas currently underway by America's transportation system.

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[6] "Methane, friend and foe for climate change," *Washington Post (*February 16, 2014).