A Commentary on "The Greenhouse-gas footprint of natural gas in shale formations" by R.W. Howarth, R. Santoro, and Anthony Ingraffea

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Natural gas is widely considered to be an environmentally cleaner fuel than coal because it does not produce detrimental by-products such as sulfur, mercury, ash and particulates and provides twice the energy per unit of weight with half the carbon footprint during combustion. In their recent paper in Climatic Change Letters, Howarth et al. (2011) challenge the last part of this consensus, contending that shale gas has a larger GHG footprint than coal, and that this larger footprint "undercuts the logic of its use as a bridging fuel over the coming decades".

The basis of Howarth et al's contention is that shale gas emits 1.9% of a well's ultimate production during well completion (whereas a conventional well emits 0.01%), while methane losses at the well site and during processing, storage, and distribution for all wells (conventional and unconventional) total between 1.7 and 6% of a well's ultimate methane production. Thus according to Howarth et al. between 3.6 and 7.9% of the methane from a shale gas well is vented to the atmosphere in the process of recovery and delivery to the customer. Converting this methane leakage to an equivalent addition of CO_2, and adding the CO_2 released when the methane is burned, Howarth et al. calculate that the greenhouse impact of shale gas is equal to or twice that of obtaining the same amount of heat by burning coal.

We have prepared a commentary on Howarth et al.'s letter in Climatic Change that has been accepted) for publication. Because of the interest in this subject, and because it will take some time for Howarth et al. to prepare their response, at which time our commentary and their response can be published simultaneously, we here summarize the arguments we make in our commentary for immediate release.

The first problem with the Howarth et al. analysis is that coal is used almost exclusively to generate electricity, so any comparison of gas to coal needs to be done in terms of the electricity the two fuels can individually generate. Since methane can drive a gas turbine (jet engine) and then a steam turbine, it can generate electricity with about twice the conversion efficiency as coal.

The second problem with the Howarth et al. analysis is that they convert methane leakage to its CO_2 equivalent using a 20 year Global Warming Potential (GWP) which does not capture the fact that methane has a lifetime in the atmosphere of a few decades whereas CO_2 resides in the atmosphere for centuries. Since we will need to live with CO_2 additions for a very long time whereas methane additions will be quickly removed, it is more appropriate to use a 100 year GWP, as is done by most workers in this field. The 100 year GWP conversion from methane to greenhouse-equivalent CO_2 is 3.2 times smaller than the 20 year GWP conversion which Howarth et al. use.

Finally Howarth et al. assume implausibly high leakage rates and fail to provide any clear evidence of methane leakage from shale gas wells during completion, or from all gas wells during handling, transmission, storage, and delivery of the gas, that would significantly increase the greenhouse impact of simply burning the methane. Moreover, they dismiss the impact of existing technology for reducing whatever emissions are now problematic.

For high volume shale gas wells the leakage rates they assert are routine would indicate about a million dollars of methane is routinely vented to the atmosphere from each high volume well. Not only is this an economic loss no business would contemplate, it represents a risk no company (or their insurer or regulator or rig workers) would accept. The methane release they suggest over a 10 day pre-production period would fill a square mile with an explosive mixture of 5% methane to a height of 176 ft from a single high volume well.

Howarth et al's estimates of substantial volumes of vented gas are all taken from reports documenting capture. Since there is practically no discussion of this point in their paper, they apparently assume such capture is rare, and that general practice involves releasing such unburned gas to the atmosphere. They document no instance of this kind of substantial methane release, which they assert is routine. In reality, for safety and economic reasons, capture/flaring is the common industry practice, and leakage during well completion of a shale gas well is probably ~0.2% of lifetime production, and could be made even smaller (e.g., closer to the 0.01% Howarth et al. cite for conventional gas wells). This is very different from the 1.9% of total production Howarth et al. suggest occurs in bringing a shale gas well into production.

The losses during handling (on and off site), transmission, storage, and delivery for both shale and conventional wells are probably ~2% of lifetime production. The total leakage is thus ~2.2% of total production for both conventional and unconventional sources, a figure which corresponds to the most recent estimate of the EPA(2011), and which falls below the range (3.6 to 7.9% of lifetime production) suggested by Howarth et al.

Figure 1 compares the greenhouse impact of coal and gas on the basis of electricity generation using the same methods as are used in Howarth et al. The figure shows that gas is only as bad as coal from a greenhouse perspective if a short (20 yr) GWP and a high leakage rate (7.9% of total production) are assumed. The leakage (top green part of the bar) in the column labeled "Howarth et al." is 11.5 times larger than in column 9 because Howarth et al. assume 3.6 fold larger leakage (7.9% rather than 2.2%) and a 3.2 times larger conversion from leaked methane to its greenhouse CO_2 equivalent (20 rather than 100 year GWP). Without these extreme multipliers, gas has ½ to 1/3rd the greenhouse impact of coal (columns labeled "this comment" in Figure 1). The rightmost two columns in the figure show that when the leakage approaches 2% (as it probably is now), the methane leakage does not add substantially to the greenhouse footprint of the CO_2 generated during combustion (blue bottom part of the bars).

Howarth et al. were correct to highlight concerns that leakage of methane during production and transmission could significantly affect the greenhouse impact of natural gas, especially gas extracted from shales. And we concur with them that much better data is needed to monitor this leakage. However, our review of their own sources finds no evidence that gas is being vented directly into the atmosphere at rates that could justify their conclusions. In contrast their sources make clear that there are effective technologies to reduce methane emissions to the point they are an insignificant addition to methane's greenhouse combustion footprint, if indeed this is not already the case. More reasonable estimates of production losses, and more appropriate bases of comparison (electricity and a 100 year GWP) show natural gas, including shale gas, has half to 1/3rd the greenhouse impact of coal, and thus remains an attractive transition fuel to low carbon alternatives.

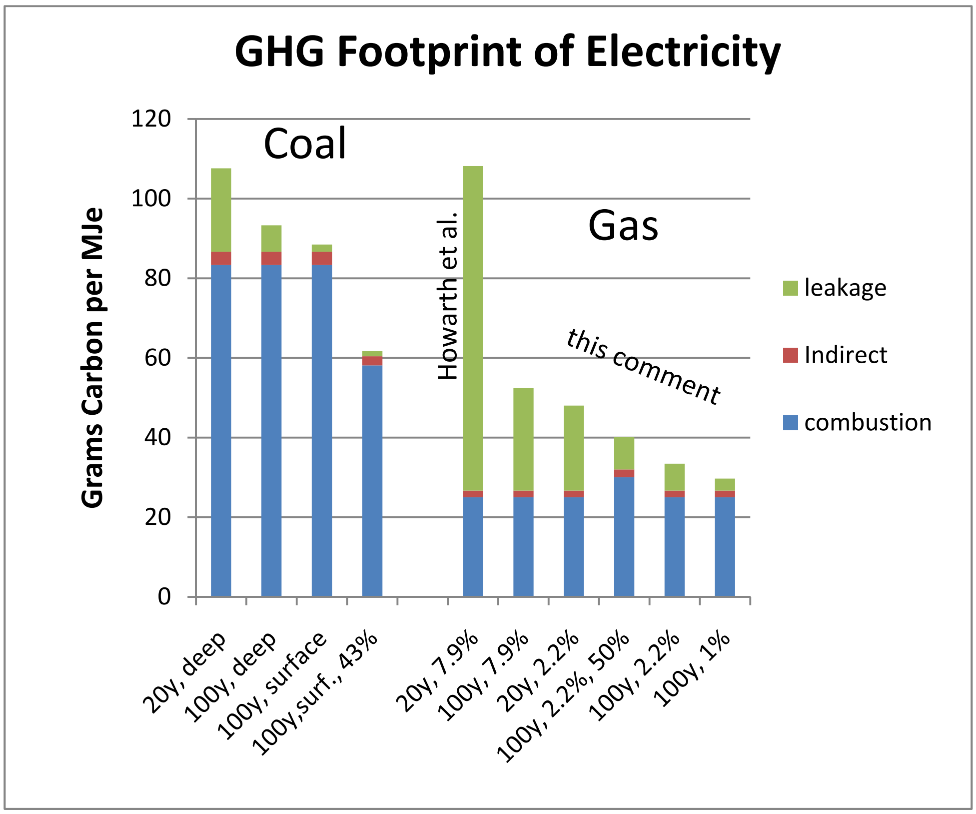

Figure 1. Using the same methods as in Howarth et al., but a more likely leakage rates of 2.2% and a 100 year global warming potential factor (GWP) for methane which captures the long residence time of CO2 compared to methane in the atmosphere, shale gas has about 1/3rd the greenhouse impact of coal when compared on the basis of how much electricity the two fuels could generate (9th column compared to first three columns). Shale gas has a GHG impact half that of the most efficient coal-electricity plant that could be constructed (column 4). Shale gas has a greenhouse impact comparable to that of coal only if a 20 year GWP and very high methane leakage rates (7.9%) are assumed (column labeled Howarth et al.). This column becomes twice the height of the coal columns if the fuels are compared in terms of their heat content (not illustrated). A 60% conversion efficiency for electricity generation in gas plants is assumed except in column 8 where the conversion efficiency is 50%. Coal conversion efficiency is 30% except in column 4 where it is 43%.

References Cited

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