Methane Production Related to Shale Gas Life-Cycle: Environmental and Economic Implications.

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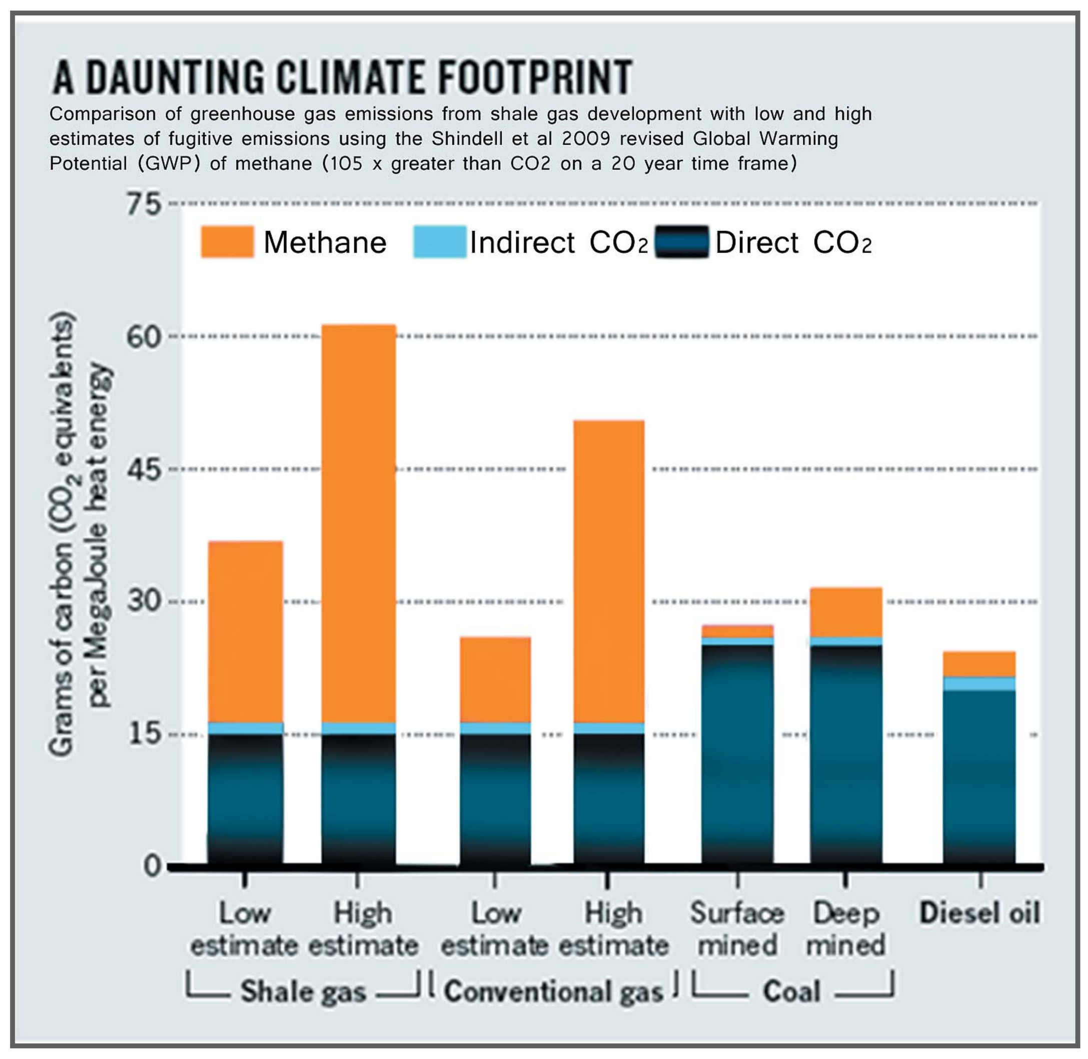
Background

Natural gas is widely proposed as a clean bridge fuel to a lower carbon economy; however, the full life-cycle greenhouse gas (GHG) emissions of shale gas development is poorly constrained and suffers from a chronic lack of information.

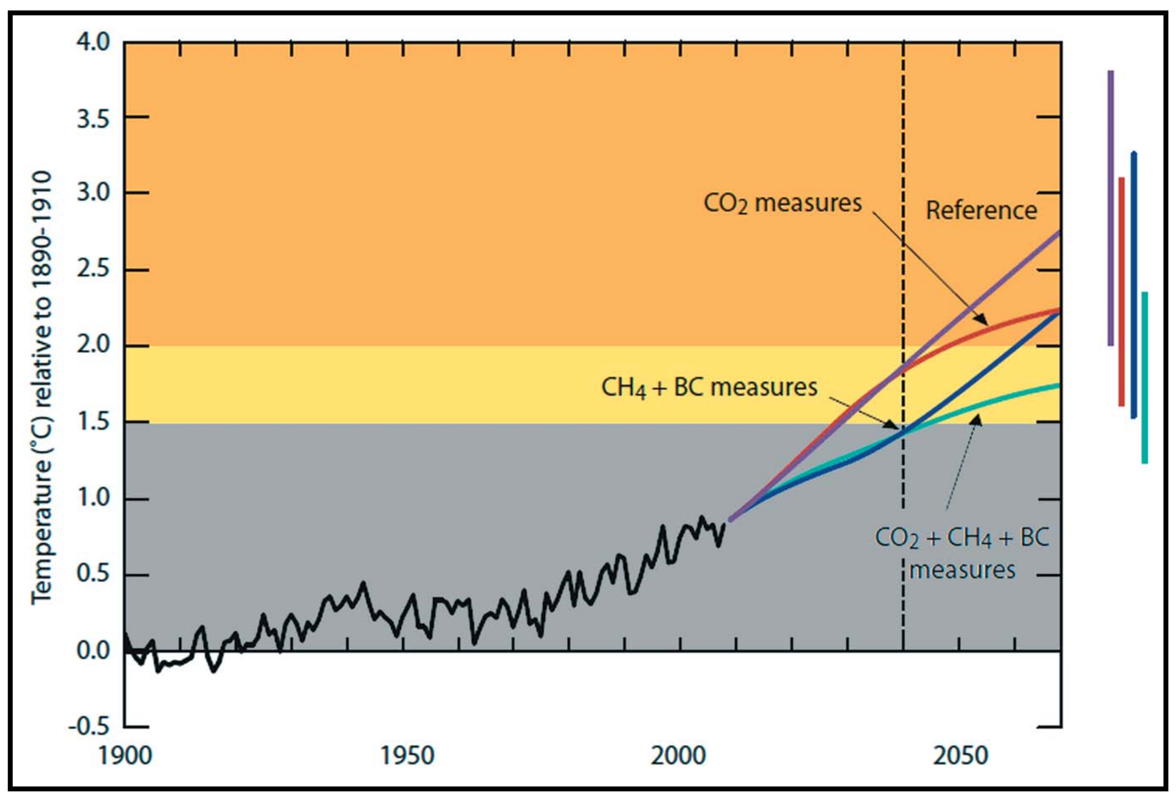
The most recent science indicates:

- **Immediate control of short-lived climate forcers such as methane is essential** to limit long-term climate change (UNEP/WMO, 2011).
- The 20 year **global warming potential (GWP) of methane is 45% greater than that reported by the IPCC 2007** when interactions with aerosols and other indirect effects are considered (Shindell et al. 2009)
- The **fossil fraction of the global methane budget may be 50% greater than previously thought and is increasing** (Lassey et al. 2007)
- Fugitive methane emissions related to shale gas development may be **30% to 2-fold greater** than that of conventional gas (Howarth et al 2011)



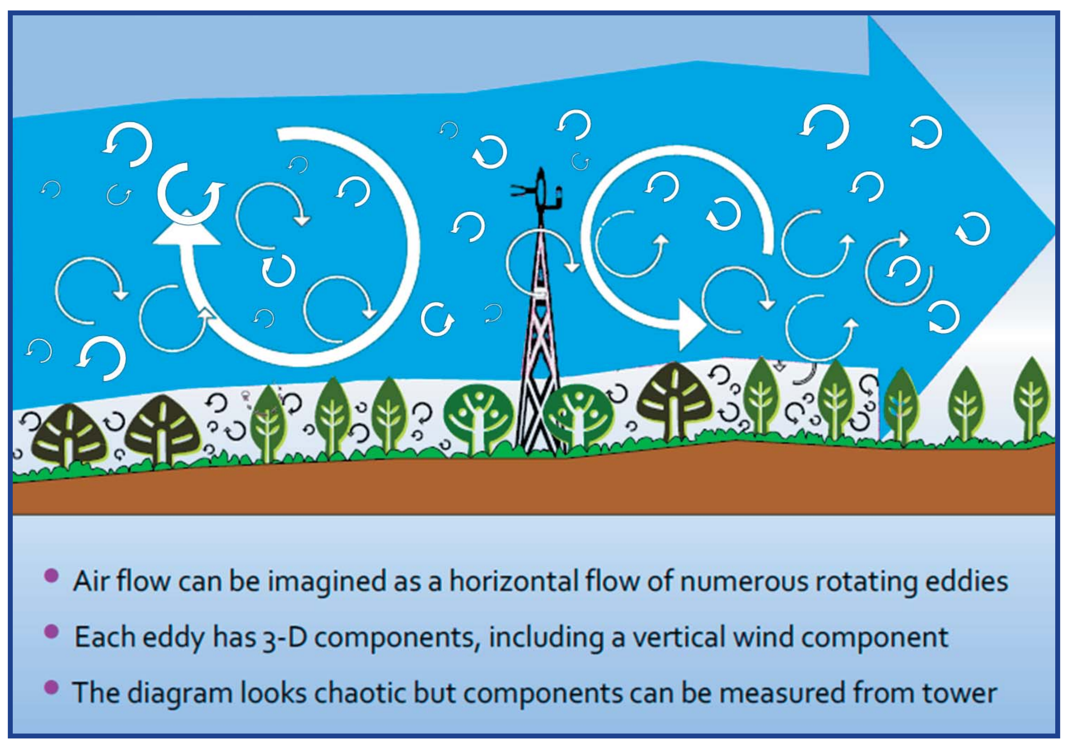
Methane emissions from shale gas development are at least 30% higher than that of conventional gas and the full life-cycle GHG impact of gas is worse than any other fossil fuel on a 20 year timeframe; Source: Howarth et al (2011).

Importance of short-lived climate-forcing gases



Observed deviation of temperature to 2009 and projections under various scenarios show that immediate controls on short-lived climate forcing species combined with reduced CO2 emissions (green line), provides the best chance of keeping Earth's temperature increase to less than 2°C relative to pre-industrial levels. Source: UNEP/WMO (2011).

Eddie co-variance measurements



The eddy covariance method [above; source: Burba and Anderson (2005)] takes advantage of the way air behaves near the surface of the Earth. The surface is rough and slows down the air and causes it to rotate or 'eddy'. Simultaneous measurements of the direction (up or down) the air is moving and the concentration of a gas of interest (e.g., carbon dioxide, methane, etc.) can be used to calculate the net movement of the gas. For the measurement to be robust, the measurements must be made at very high rates (> 10 measurements per second). Therefore, in the case of methane we measure the wind speed and direction using sound and the concentration of methane using the absorption spectrum of a precision laser [below]

Methane emissions from shale-derived gas

Natural gas is invisible to the naked eye, so infared cameras are often used to detect leaks in the system; here an infared video camera captures the completion vent from Marcellus gas well. Still taken from video footage courtesy Frank Finan.

Primary Goal

Quantify the flux of methane to the atmosphere associated with shale gas development

Approach

We will use the eddy covariance method to measure the flux (i.e., degree of transfer to the atmosphere) of methane downwind of areas of intensive hydrofracturing activity and downwind of areas not experiencing hydrofracturing. Measurements from both areas will reflect other methane sources (e.g., wetlands, cattle production, etc.) and the difference between sites will represent the contribution of hydrofracturing to total methane emission.

All measurements will be made from a portable tower system that can be moved among sites. On the tower is a high precision sonic anemometer for the measurement of wind speed and direction and a laser-based methane instrument. The combination of these instruments (pictured to the right) allows for an integrated measurement of total methane flux and accounts for both methane emission (methane entering the atmosphere) and methane consumption (methane returning and consumed at the surface).

We will coordinate our measurements with well operations to gain insight into the flux rate during different phases of the hydrofracturing process.

Future Related Work

Re-assess the global methane budget - We will use the eddy measurements of methane flux from well sites as well as the most recent literature values for other methane sources and isotopic composition of atmospheric methane to update the global methane budget.

Economic implications - using the emissions data from the previous methane analyses, we will conduct a sensitivity analysis explicitly considering the interaction of methane emissions with a carbon tax

References

Burba G. and D. Anderson (2005). A Brief Practical Guide to Eddy Covariance Flux Measurements: Principles and Workflow Examples for Scientific and Industrial Applications. LI-COR Biosciences, Lincoln NE USA
Howarth RW, Santoro RL, Ingraffea AR (2011). Methane and the greenhouse-gas footprint of natural gas from shale formations. Climate Change 106: 679-690.
Lassey KR, Lowe DC, and Smith AM (2007). The atmospheric cycling of radiomethane and the "fossil fraction" of the mathane source. Atmospheric Chem. & Physics 7:2141-2149
Shindell DT, Faluvegi G, Koch DM, Schmidt GA, Unger N, and Bauer SE (2009). Improved attribution of climate forcing to emissions. Science 326: 716-718.
UNEP/WMO (2011). Integrated Assessment of Black Carbon and Tropospheric Ozone: Summary for Decision Makers.

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